Vol. XIX, Part VI November, 1924

THE AGRICULTURAL JOURNAL OF INDIA

EDITED BY

The Agricultural Adviser to the Government of India

PUBLISHED FOR

THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

BY

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SOME COMMON INDIAN BIRDS.

No. 30. THE ROSE-RINGED PAROQUET (*PSITTACULA TORQUATA*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist;

AND

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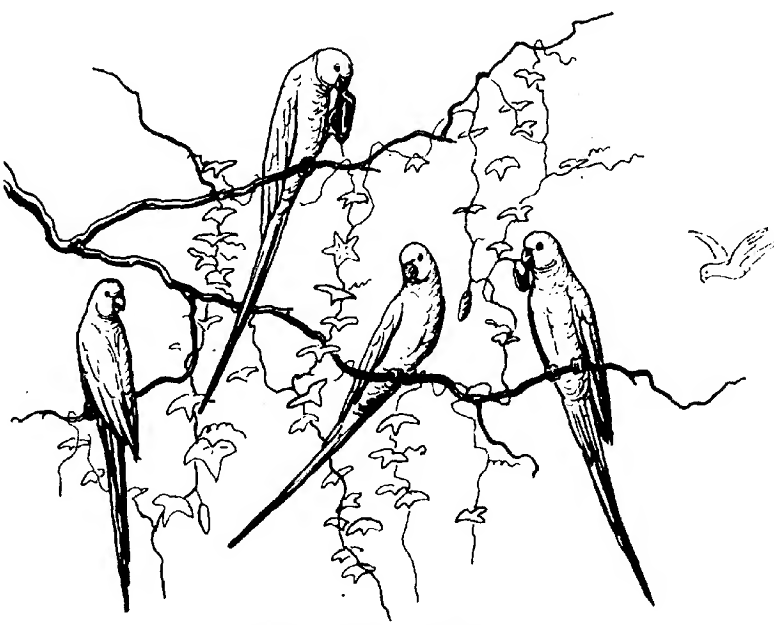
THE great family of the Parrots is so widely distributed throughout the Tropical Regions of the World and is composed of so many different species that it is difficult to say why the Indian list of indigenous forms should be so scanty, only a dozen species, represented by nineteen sub-species, being known to occur. But perhaps it is well that we have no more; for, as Dewar remarks, "the green parrot is one of those good things of which it is possible to have too much."

Parrots are sharply distinguished from all other classes of Birds by several anatomical peculiarities in their vertebræ, feet, and other parts, into which we need not enter here. Most Indian Parrots are easily recognizable as such, their most obvious characters being the short, stout, strongly-hooked bill, thick fleshy tongue, movable upper mandible, climbing habits, and (in most species)

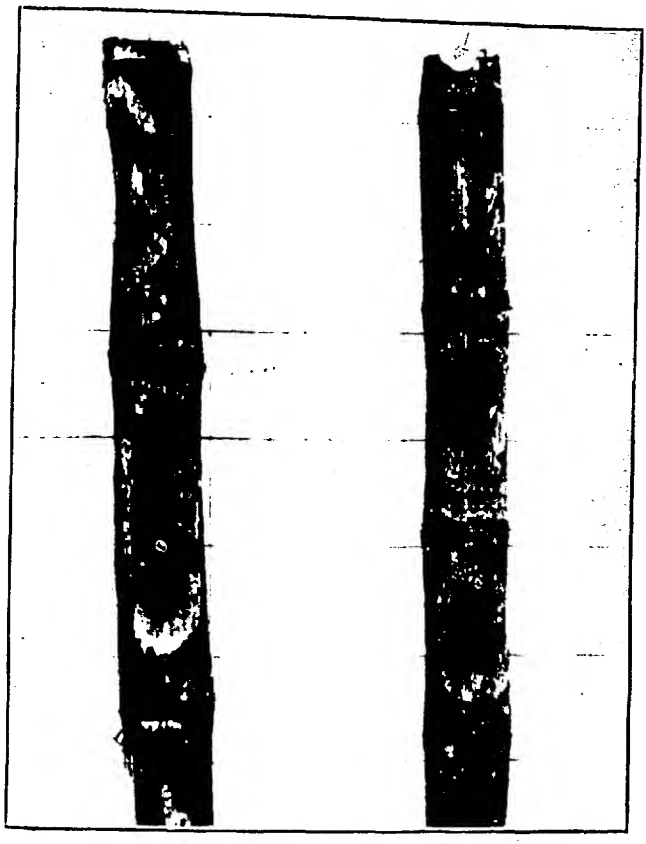
long tail and greenish colour. The subject of our present article may be distinguished from all other Indian Parrots by its long tail, head (except chin and mandibular stripe in males) and body green, bill deep red, with no red patch on the wing-coverts. It is by far the commonest and most familiar of the green Indian Parrots, occurring abundantly in all open and cultivated land around towns and villages, often in large flocks, dashing over the tree-tops in swift, arrowlike flight. It is found practically everywhere throughout the Plains of India, Burma and Ceylon, but seems to be commoner in Northern India than in Madras.



Rose-ringed Paroquets attacking wild fruits.

Wherever it occurs, however, in its wild state the Rose-ringed Paroquet is an unmitigated nuisance, as its diet is wholly vegetarian and it feeds largely on cultivated grains and fruits. When a large flock descends on a ripening crop of *juar* (sorghum) or similar cereal,

a great deal of damage is done, some by the actual grain that is eaten, but far more by the extremely wasteful method of feeding of this bird, which often breaks off a whole head, delicately



Sugarcane damaged by parrots in Assam (From a photograph by Dr. C. A. Barber).

selects one or two grains, throws away the rest, and breaks off another head which is treated in the same way. When fruits are ripe, these birds soon find them out and play havoc with them.

When no cultivated fruits or crops are in season, the food consists of wild fruits (wild figs, *Zizyphus*, etc.) and seeds. The late Mr. C. W. Mason examined fifty-three birds at Pusa and Mr. D'Abreu three more at Nagpur, and in all cases the stomach-contents consisted entirely of vegetable matter—mustard, wheat, maize, paddy, litchi and wild fruits, and seeds of *Dalbergia sissu.* When the silk-cotton trees are in flower in February these parrots are amongst the crowd of birds which congregate to imbibe the nectar. We have not yet had any complaints of its attacking sugarcane but, with the increasing cultivation of this crop in Bihar, it will perhaps discover that it is edible and attack it in the same way as another Parrot has damaged sugarcane in Assam, by gnawing large holes in the stems.

The Rose-ringed Paroquet does not deserve, nor has it been afforded, any protection under the Wild Animals Protection Act: on the contrary, its destruction should be encouraged and, if this could be done by exempting the export of its plumage from the present Customs restrictions, or in any other way, it would be all to the benefit of the cultivator who is practically powerless at present to prevent the immense damage done to his crops by this destructive bird.

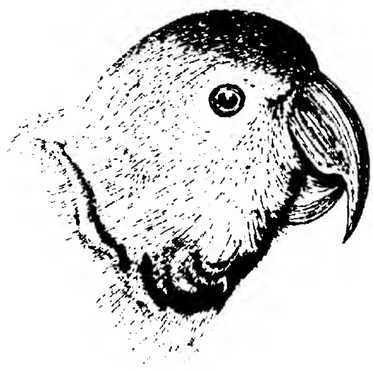
It must be admitted, however, that from a purely æsthetic and non-utilitarian view-point the Rose-ringed Paroquet is a decidedly handsome and attractive bird when seen under natural conditions flashing through the sunshine or climbing over a tree in search of food, and, in places where its numbers are but small, its brilliant hues, delicate outlines and dainty ways provide a perennial source of joy to the bird lover. But in country districts, where it is only too abundant, its destructive habits and shrill harsh screams very quickly nullify such feelings of admiration.

As a cage-bird the Rose-ringed Paroquet is a favourite all over India, and thousands of young birds must be taken every year from their nests and doomed to pass the remainder of their existence within prison bars, although unfortunately this annual toll seems to make little difference to the total numbers which exist to ravage the farmer's crops. As its powerful beak soon secures its escape

from a wooden cage, this bird is usually kept in a small dome-shaped cage made of hoop-iron, with a sheet-iron floor, which must get uncomfortably like an oven in the hot weather. With a little instruction, this parrot often becomes a good talker, and it can also be taught to perform tricks. Lockwood Kipling tells of one that he used to see in the streets of Delhi "that went through gymnastic and military exercises, whirling a tiny torch lighted at each end, loading and firing a small cannon, lying dead and coming to life again; all done with a comic air of eagerness and enjoyment which it seemed hard to impute to mere hunger for the morsels that rewarded each trick."

The Rose-ringed Paroquet breeds in January and February in Southern India, from March to May further North. No regular nest is made but the eggs are laid in a branch of a tree, occasionally in a wall. If a suitable hole is already available, the birds appropriate it, and couples may often be seen, at Pusa about the end of February every year, inspecting eligible sites, which by that time are often occupied by Hoopoes. If no acceptable hole can be found, the birds may excavate one for themselves and Colonel Butler noted a pair at Deesa which were at work clearing out the hole, in which the eggs were subsequently deposited, for at least three months before the eggs were laid. A finished hole, either acquired or excavated either wholly or in part, is generally about two inches in diameter, and goes straight into the trunk for two to four inches and then turns downward for a distance of six inches to three feet, the lower portion being expanded into an egg-chamber which is four or five inches in diameter. Should a natural hollow in the tree be utilized or cut into, the chamber may be much larger. The entrance-hole is cut either into the trunk of a tree or into a large bough; in the latter case it is often placed on the lower side of the bough. No lining is provided, the eggs being laid on a few chips of wood at the bottom of the hole. The usual number of eggs is four but as many as six are found at times. The egg is pure white, without any gloss, usually in shape a moderately broad oval, considerably pointed towards one end, and measures about 30 by 24 millimetres.

Our Plate shows both sexes of this Paroquet, the adult male being distinguishable by his rosy collar which is absent in the female.



Head of male Rose-ringed Paroquet.

DAIRY EDUCATION IN DENMARK.*

BY

N. KJAERGAARD JENSEN,

Professor in Dairying, Royal Veterinary and Agricultural High College, Copenhagen.

WHEN speaking about dairy education in Denmark, one must unavoidably divide it into two parts—first, the low (inferior or junior) education, whose object is to provide the dairy industry with dairy managers, practical dairymen, and second, the high (superior or senior) education, which prepares lecturers for dairy colleges, graduates in dairying, etc.

The low education can again be subdivided into practical and theoretical education.

The practical education has been for many years entirely free and planless. A dairy could keep as many apprentices as it chose to and at the same time the period of apprenticeship was not fixed, nor was it obligatory for the apprentice to learn or the instructor to teach butter and cheese-making as well as other dairy work in a specially stipulated period.

The planlessness of such education drew the attention of the dairy circles, and the Danish Dairymen's Association (Association of the Dairy Managers) decided to have this position improved. In 1910, the Board of the Association took the initiative into its own hands and worked out a scheme proposing a four years' period for apprenticeship. The scheme was accepted and approved, but at first it continued to be only voluntary whether the apprentice wished to learn under the supervision of the Association or not;

* Paper read at the World's Dairy Congress, 1923.

from 1918, however, the four years' apprenticeship became compulsory.

The rules for such education for the teacher are the following: Each member of the Danish Dairymen's Association undertakes to instruct an apprentice in all dairy work as thoroughly as possible and instruct him also in accountancy and recording of the dairying operations. The instructor is also obliged to have literature on dairy industry which is to be kept at apprentice's disposal.

The programme for apprenticeship stipulates the period of such to be four years. During the first year all kinds of dairy work are to be gone through. After that comes a year of learning butter-making, followed by another year for cheese-making and then the last year in which the apprentice learns some engineering—machinery, engines, heating, etc.

It is not necessary for the apprentice to go through the four years' work in the order mentioned above, but it is absolutely compulsory that a whole year is spent in learning each of the four subjects named. The apprenticeship must be done in at least two and not more than three different first class dairies. The last three years the apprentice must keep the dairy accounts as well as record all milk and products through all operations.

At the end of the fourth year the young dairyman receives a "certificate of apprenticeship" signed by the Board of the Association.

As already mentioned, before 1918 every dairy had the right to keep as many apprentices as it chose, but from that year it was agreed upon between all the dairy organizations that the number of apprentices at each dairy had to be limited to a certain point in proportion to experienced dairymen, so as to ensure that at any time given all dairies have a sufficient staff of experienced dairymen to conduct and supervise the work of the dairy.

The theoretic education began in 1889, when the now deceased President of the Ladelund Agricultural College, Mr. Niels Pederson, founded the College of Dairy Education by opening a five months' course for future dairymen for theoretic education solely. The programme of the course comprised chiefly: chemistry, physics.

treatment of domestic animals, machinery and instruction in dairying. This five months' course for dairymen was continued parallel with the agricultural course till 1910 when the Dairy Associations intervened owing to the rapid development of the dairy industry. They approached the two existing colleges with a suggestion that a more thorough system of education was required, and it was agreed to have the period of training extended to eight months, namely, from 1st September to the end of April. This arrangement was brought into effect in both colleges from 1st September, 1910, and has continued to the present day. It was also decided to put the system of education in both colleges on an equal footing and have the students examined on every subject once a year by a body of examiners representing both colleges. The students in these colleges are instructed in theoretical and practical chemistry and bacteriology, physics, treatment of domestic animals, machinery, commercial calculations, and accountancy; also attention is given to writing, arithmetic, drawing and gymnastics.

The working day in such a college is arranged as follows: lectures from 8 a.m. to noon with 10 minutes' recreation between each lecture; from noon to 2 p.m. is allowed for dinner and recreation, and the lectures are continued from 2 to 6 p.m. In the evening the students must read and prepare themselves for the next day. They are enrolled to attend at every lecture and should something prevent a student from doing so, an instructor or the director of the college has to be informed of the cause.

THE ADVANCED EDUCATION.

Up to the year 1904 all students who desired to become lecturers or graduates in dairying received the same theoretical education as an agricultural student at the Royal Veterinary and Agricultural High College in Copenhagen. The syllabus comprised: chemistry, physics, geology, botany, zoology, anatomy, mensuration and levelling, drawing, mathematics, cultivation of plants, horse-breeding, treatment of domestic animals, dairying and agricultural book-keeping, general agriculture as well as agricultural chemistry. The normal course continued about twenty months and finished

with two examinations. The first examination covered general education and took place after about nine months' attendance; the second examination was devoted to the remaining subjects and was held at the end of the course.

On 1st September, 1904, a supplementary course for agricultural students wishing to graduate in dairying was founded. To attend this course it was obligatory for the student to possess sufficient knowledge of German and English to enable him to read books written in these languages.

Before being admitted to the examination following the last course, the student has to pass first the agricultural examination, as well as show evidence of high character. The period for this course is also twenty months and includes the following subjects: physiology, agricultural chemistry, pathology, treatment of domestic animals, bacteriology, country law, political economy, practical work in chemistry and bacteriology, and drawing. The course is followed by an examination.

But the Dairy Associations were not entirely satisfied with the arrangement that a dairy student was obliged to follow a training in agriculture before beginning his special studies in dairying. Necessary steps were undertaken by the Danish Co-operative Dairy Association to have the above arrangement altered. The Royal Veterinary and Agricultural High College in Copenhagen immediately declared itself willing to support the Association. The position was considered and new rules were issued to commence from 1st September, 1921.

The new course spreads itself over two to three years. However, before passing the examination the student must go through a practical education which is to be approved of by the Royal Veterinary and Agricultural High College. This practical work is expected to take at least four years after the student has reached the age of 15, or three years after he has attained his 17th year.

The period of education is divided into two parts; the first continues for eighteen months and the following subjects are studied: physics, meteorology, chemistry, geology, botany, microbiology,

laws of heredity, zoology, anatomy of domestic animals and physiology, political economy, agricultural chemistry, practical work in physics, chemistry and bacteriology, and drawing. The second part continues for about eighteen months, and deals with the treatment of animals, management of the dairying industry, dairy chemistry and bacteriology, also agricultural geography, general agriculture, pathology and practical work in machinery, house-building, general agriculture, agricultural chemistry, dairy chemistry and dairy bacteriology.

The first graduate in dairying educated under the new rules completed his studies on the 1st of May, 1924.

Before closing this short contribution it must be mentioned that also in the Copenhagen Polytechnicum, students studying to be factory engineers go through a course of dairying under the guidance of Professor Orla-Jensen, PH.D.

THE CONTROL OF COTTON PESTS IN NORTH INDIA.*

BY

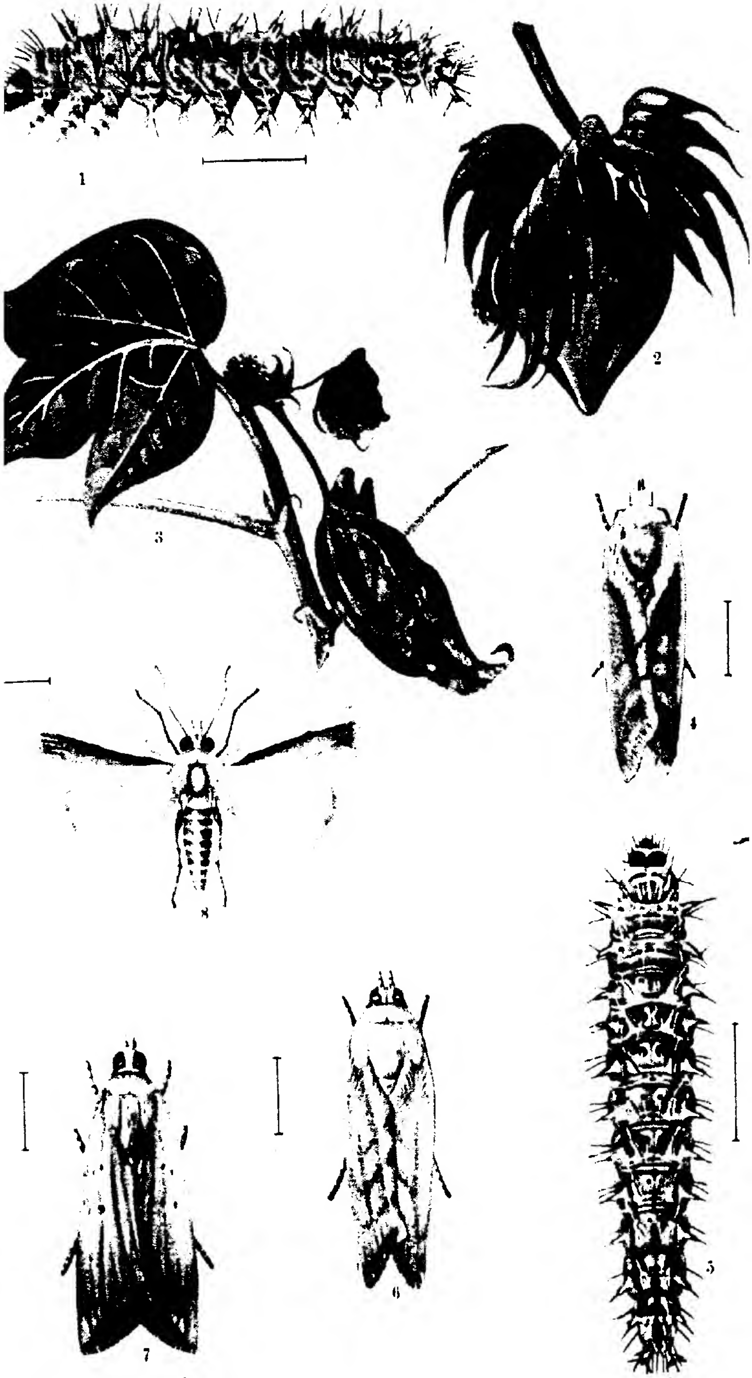
P. B. RICHARDS, A.R.C.S., F.E.S.,
Entomologist to Government, United Provinces.

It is unnecessary to labour the importance of the Indian cotton-growing industry, either to the welfare and wealth of India itself, or as a factor in world economics. Everyone knows how essential it is that cotton should be produced in India to satisfy the requirements of the mill and home spinning industries for clothing the millions of this country ; it is common knowledge to most of us that the world's markets are hungry for more cotton, and that world-wide efforts to find new fields of supply are being made ; and it may have been noted that a demand for Indian-grown cotton is arising in the English market. The increase in quantity and quality of the Indian cotton crop is thus of paramount importance to the producer, consumer, industrialist and economist alike.

Improved methods of cultivation, improved varieties, and increase of area are the more obvious means of increasing the supply ; but to those who have given no attention to the effect of insect attack upon the yield of cotton, it may be a surprise to hear that the control of insect pests would be equivalent to increasing the total area by 30 to 50 per cent. In other words, the soil already under cotton cultivation produces annually one-third to one-half more cotton than ever finds its way to the looms. Instead, it serves to feed a horde of insects.

The insects which attack the cotton plant are numerous and diverse. Among them are species of grasshoppers, white ants, bugs, beetles, butterflies, and moths ; they eat the roots, stems, leaves,

* Paper read at the Agricultural Section of the Indian Science Congress, Bangalore, 1924.



EARIAS INSULANA.

PLATE XVII.

1. The boll-worm.
2. An attacked boll, showing the [illegible] of excreta thro[illegible]
3. An attacked shoot, the worm being [illegible]
4. A moth with closed wings, as it rests on the plant.
5. Another [illegible] of the [illegible]
6, 8. The [illegible]
7. The moth of a similar but distinct species which does not attack cotton.

EARIAS INSULANA.

flowers, seed and lint, suck the sap, and abstract the contents of the seeds ; and they vary in size from minute bugs of a twentieth of an inch in length to ponderous beetles of an inch and a half. Fortunately all are not equally numerous and rapacious. The bulk of them may be regarded as of very minor importance, and so far as the North of India is concerned, the really bad offenders may be said to be two, both the larvæ of moths. These larvæ are commonly known as the Spotted Boll-worm and the Pink Boll-worm.

The Spotted Boll-worms (Plate XVII) are the caterpillars of three species of *Earias*,* a genus of the family Noctuidæ. The first Spotted Boll-worms appear in the cotton fields when the seedlings are young, and damage the plants by boring into the stem, thus killing the main shoot. Later they attack the flower-buds, flowers, and young bolls, completely eating out the contents of buds and bolls, leaving the empty shells, and wandering over the plant in search of fresh supplies, each individual thus destroying many potential bolls during the three weeks or so which it takes to reach the full-fed condition prior to pupating. At this time it is a fat, thick-set caterpillar of a dull grey colour, dotted all over the dorsal surface with irregular brown dots, and measuring about two-thirds of an inch. It comes out of its last boll, spins a canoe-shaped cocoon of brown silk concealed among dead leaves or flowers, pupates, and within a fortnight the moth emerges. Descriptions of the adults may be found in Lefroy's "Indian Insect Life" or Fletcher's "South Indian Insects." They are nocturnal, and are not much attracted to light or other traps, so it is not possible to deal with them in the adult condition. The fertilized female lays very beautiful small blue eggs, singly, on the leaves and bracts of the cotton plant, from which emerge a new generation of caterpillars to continue the mischief.

The fecundity is considerable, and the rate of generation rapid. One female lays sixty to eighty eggs, and in four weeks or so a generation is complete. It thus seems that as the caterpillars

* *Earias fabia*, Stoll ; *E. insulana*, Boisd. ; *E. cupreoviridis*, Wlk.

can theoretically increase in powers of 30 every four weeks, and each caterpillar can destroy several small bolls or one or two large ones, there would not be sufficient bolls produced to satisfy the demands of the third or fourth generation. Fortunately Nature does not work in this way the theoretical rate of increase is not maintained for any length of time unless under very exceptional conditions. Various natural controlling factors operate to check the rate of increase in normal seasons. A little further enquiry into the habits of the Spotted Boll-worm will show how some of these work.

The larva, when it emerges from the egg, is a minute creature about one-tenth of an inch long with a slender, bristly body. It will be remembered that the eggs are laid singly on the leaves and bracts. In most varieties of cotton the leaves are hairy. Many of the young caterpillars appear to obtain their first food from the tissues of the leaf on which they were hatched. Now, if the leaves are densely pubescent, this is a matter of difficulty, as the caterpillars are not easily able to reach the epidermis. The leaf tissue does not in any event satisfy the insect long. After a small feed it proceeds to seek a bud or boll into which it may burrow. Here again its progress is much hampered by the hairs of the leaf. A considerable number of the caterpillars thus fail to arrive at a bud or boll at all, especially in hot sun or during rain. The more successful individuals which do succeed in reaching a bud or boll eat their way into the centre of it, making a round entrance hole which remains open, and out of which may frequently be seen protruding a quantity of yellow or brown frass. During the early days of the insect's existence, it usually selects buds in preference to larger bolls. Having completely eaten up the contents of one, it comes out and wanders in search of further food.

Finally the caterpillars of the later generations tunnel their way into well-developed bolls, eat the seeds, sometimes of the whole boll but more frequently of one or two of the loculi, and fill the cavity with a mass of brownish excrement. The destruction of the seed, of course, involves the lint. It is probably in such larger bolls that the damage done is of greatest importance to yield and quality.

During its peregrinations the caterpillar is, of course, exposed to attack by insect-eating birds, and predaceous and parasitic insects. Moreover, the younger attacked bolls readily fall from the plant, and many caterpillars, especially during wind or heavy rain, fall to the ground within the bolls. If there be standing water in the field, most of such caterpillars are drowned. This often affords a very effective check, wiping out a considerable proportion of the pest.

An appreciable natural check is that of parasitic Hymenoptera, species of *Rhogas*, which lay eggs on the caterpillar from which emerge grubs which slowly consume its body. These parasites do not appear to be sufficient in themselves to keep the pest in check. So far as I know, no accurate determination of their effectiveness has been attempted, but it is estimated to be about 10 per cent. It is probable that, under optimum conditions, it will prove to be considerably higher in certain areas. It is, at the least a useful helper in the good work.

There is another probable check of which at present we know very little. Many Spotted Boll-worms are often found dead within the bolls. This is especially the case after a period of damp weather, and it is inferred that fungi or bacteria are responsible. It should be remembered, in this connection, that the large hole made in the boll wall on entry remains open, and that water, fungus spores, and bacteria can thus readily enter the boll. There is here, perhaps, a fruitful field for investigation and experiment; but the artificial induction of an epidemic among healthy insects is a difficult and uncertain matter, involving expert technique and wide-spread spraying operations, and generally limited in effectiveness by the climatic factor.

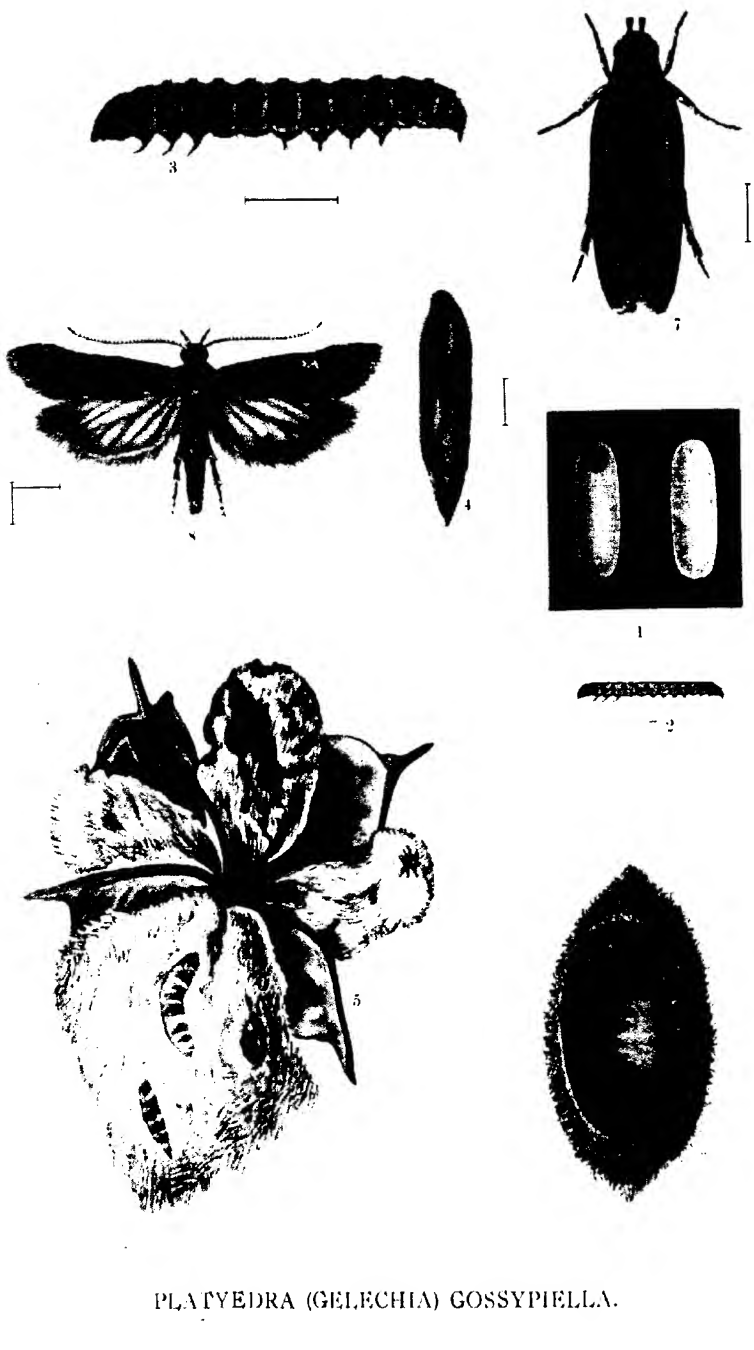
As to the actual loss of crop resulting from Spotted Boll-worm attack, I have no figures of my own; nor do I know of any critical experimental data. In the United Provinces, so far as my experience goes, I do not estimate it at more than six or seven per cent.—say, an anna in the rupee—but that is practically a guess-work figure based on observations of attack of the larger bolls. It does not take into consideration, among other possible effects, the retarding

of growth due to the original attack on the shoots of seedlings, the loss of cotton from the young bolls, the flowers, and the buds which are frequently destroyed in considerable number, or the effect upon lint production in partly consumed bolls. It is hoped that data will be forthcoming shortly which may help to determine the absolute damage and the relative importance of this pest in the United Provinces. In 1917 the Imperial Entomologist stated that in the Punjab, in some years, the damage " is very serious indeed, running into a loss of several million pounds sterling."

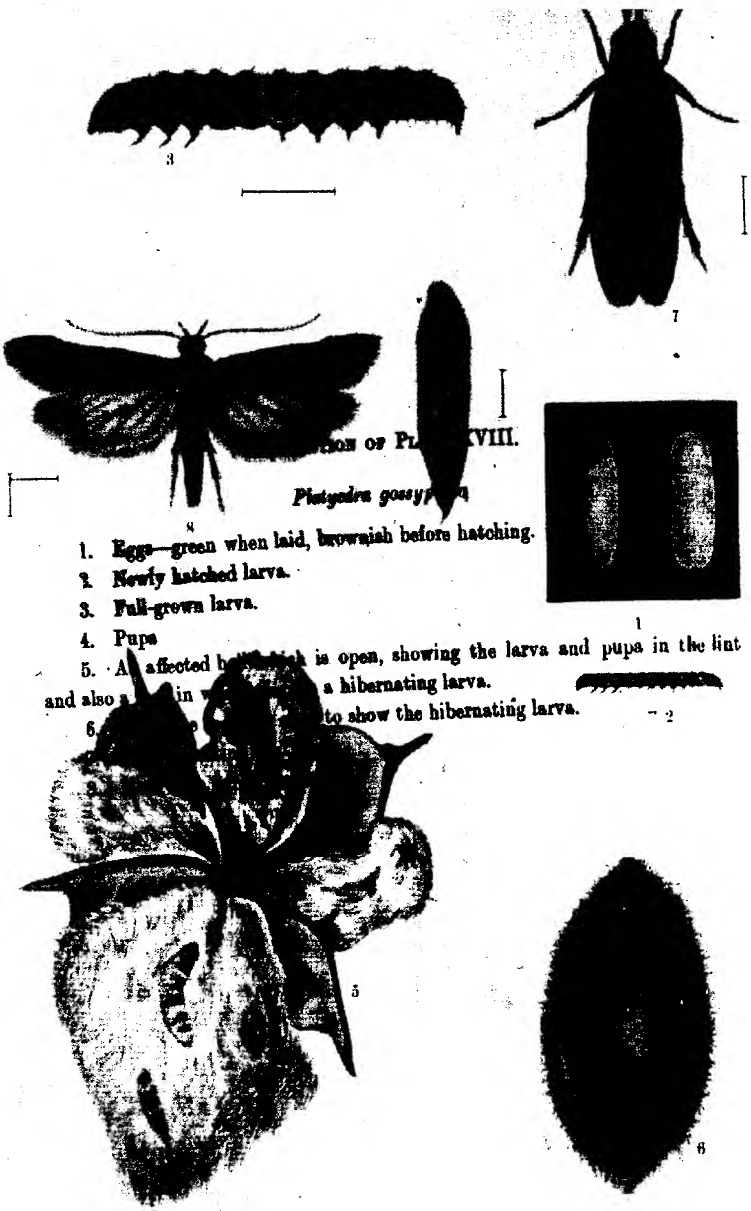
There is one more fact in the life-history of the Spotted Boll-worm to which I must direct your attention. I have mentioned that the caterpillar comes out of the boll when full-fed and pupates in a tough, cryptic-coloured cocoon of silk. It is in this condition that the insect usually survives the winter, either in cracks in the soil or concealed among dead leaves or the like rubbish. Emerging as a moth in the spring, it is usually able to recommence breeding on other plants than cotton, notably *bhindi* (*Hibiscus esculentus*) and other species of *Hibiscus*, and on *Abutilon indicum*. None of the three species of *Earias* is confined to cotton.

A consideration of the foregoing shows that, so far as investigations have carried us, no universal panacea can be evolved for the Spotted Boll-worm. Spraying or dusting the plants with poisons is of doubtful effect, entails an outlay in materials and appliances which would deter the small cultivator, and is a method involving considerable risk when employed unintelligently. The presence of the pest in wild foodplants, and its liking for such a commonly grown vegetable as *bhindi*, militate against the effectiveness of methods involving compulsory destruction of cotton sticks or rubbish after harvest. The low percentage of parasite infection puts a limit to the value of breeding and distributing parasitic insects in the cotton tracts. Trap crops have been tried with poor success; while the evolution of immune races of cotton is a dream hardly likely of realization.

The reduction of the numbers of this pest, with the consequent saving to the country of some part of the crores of rupees now said to be lost annually, appears more likely to result from



PLATYEDRA (GELECHIA) GOSSYPIELLA.



[illegible] of Pl[illegible]VIII.

Platyedra gossyp[illegible]

1. Eggs—green when laid, brownish before hatching.
2. Newly hatched larva.
3. Full-grown larva.
4. Pupa
5. A[illegible] affected b[illegible] is open, showing the larva and pupa in the lint and also a [illegible] in [illegible] a hibernating larva.
6. [illegible] to show the hibernating larva.

PLATYEDRA (GELECHIA) GOSSYPIELLA.

application of simple methods capable of being grafted on the routine agricultural practice of the cultivators. The ground should certainly be cleared of ratoon plants, cotton sticks and rubbish between seasons; the early attack on seedlings should be utilized as a trap for the first generation of the pest, either by uprooting attacked plants or by topping them below the bored part, and at once destroying the contained insects; while at each irrigation or during each heavy fall of rain the plants should be shaken to ensure the majority of attacked bolls falling off into the water, so drowning the contained caterpillars. Further good may possibly result from the selection of densely hairy varieties of cotton.

It was at first believed that the Spotted Boll-worm was responsible for most of the damage to bolls throughout North India. Investigation has, however, shown that the Pink Boll-worm is a much more pernicious and dangerous pest. This fact has long been recognized in the United Provinces, and, whether because of the spread of the pest, or through more extended observation, it is also being realized in other provinces.

The Pink Boll-worm (Plate XVIII) is the larva of a Gelechiad moth, *Platyedra gossypiella*, Saund. The moth is a small, insignificant, brown insect. four-tenths of an inch long, nocturnal, and has the habit of scuttling under shelter if disturbed by day. Although inconceivable numbers of the moths are produced every year, very few even of the folk concerned with cotton have seen the adult insect, at any rate to recognize it as the imago of the Pink Boll-worm.

In order to indicate the nature of the damage and the problems to be faced in reducing it, I must describe, as briefly as possible, the course of events throughout the twelve months from one cotton sowing to the next. I will start from the arrival of the adult moths in the cotton fields. We will see later how they get there.

The appearance of the moths follows the planting by a period of three to four weeks, dependent, apparently, upon the humidity of atmosphere and soil. Egg-laying commences coincident with the development of buds and flowers. The eggs are minute ovals, barely visible to the eye, but shown by a lens to be delicate,

net-marked, iridescent-shelled objects about half a millimetre long. Two to four hundred eggs may be laid by one female, and they are laid singly among the hairs of the bracts and stems of flowers or bolls, on the stems of the young shoots, and on the axils, petioles, and laminæ of the younger leaves. From the egg, from three to ten days after laying, emerges a white larva about one-twelfth of an inch long, with small dark head and slender flexible body. It immediately seeks a bud, flower, or boll, and proceeds to eat its way inside. In bud or flower the anthers are first attacked, but the insect may finally enter the ovary. A young bud does not afford sufficient food for the development of the larva, nor does a very young boll. From these, when consumed, an excursion has to be made in search of fresh supplies. But a single flower or an older boll provides all the necessary nourishment, and once entered is not left until the caterpillar requires to pupate. Hence, unlike the Spotted Boll-worm, the Pink Boll-worm is seldom required to leave its shelter, and is very rarely to be seen at large on the cotton plant. This is wisdom, because in the course of a few days' rich feeding, it loses its delicate appearance and becomes a stout, conspicuously pink caterpillar, which would surely prove a tempting titbit to birds, and a promising and unprotected field for the egg-laying operations of parasitic insects. But, further than this, it has learnt how to enter a cotton boll without leaving an open, tell-tale hole through which fungi, bacteria, and parasitic insects may follow to its detriment. The bore hole of the Spotted Boll-worm remains open. That made by the Pink Boll-worm very rapidly closes over, leaving practically no scar or trace by which insect, bird, or man may discover the caterpillar's presence. Its ingenuity in self-preservation extends further. The Pink Boll-worm, like its Spotted associate, eats the developing seed in the boll, but it does this in such manner that the plant is not much disturbed, and the attacked bolls are seldom loosened. Thus when a storm of wind and rain causes havoc among the Spotted population, the Pink community ride out the tempest snug and secure in their sealed and firm-fastened chambers. Nor is even this the full extent of its cunning in concealment and self-preservation. It has evolved

a means whereby it ensures its safety throughout the cold and hot seasons, and by which, at the break of the rains, the cultivator whose crop its offspring will ravish is made the unwitting agent of his own ill. In its last expression the Boll-worm's cunning may perhaps have overshot the mark, to its ultimate undoing. But I must not anticipate. These matters belong to a later chapter of the story.

To follow further this first generation of larvæ; the feeding stage occupies about twelve to fifteen days, the pink colour appearing about half way through this. The full-fed larva pupates inside a thin silken cocoon within the hollowed seed, or among the lint, the bracts, or withered leaves, or sometimes attached to the stem or in cracks in the soil. Ten days to a fortnight later the adult moth emerges, and egg-laying recommences.

A complete generation, in which the insects may increase one hundred to two hundred fold, thus occupies from twenty-five to thirty days in the monsoon. Four such generations between July and October frequently result in the production of so many Pink Boll-worms that ultimately practically every boll harbours one or more.

Towards the end of October, when the temperature begins to fall and the air to dry, a marked change of habit is noticeable in most of the larvæ. When they are full-fed, all but a few, instead of pupating at once, spin themselves snug cradles of silk inside a hollowed seed. If the seeds are small, two or more may be securely fastened together for this purpose. Within these the larvæ sleep out the cold weather and the heat, awaking to activity again only after the onset of the monsoon.

The few exceptions pupate, and moths emerge which lay eggs on such cotton plants as may be available. The development of the resulting larvæ in the cold weather is slow, but under favourable conditions two generations may be passed through during the winter; while, if the cotton is left in the ground through the hot weather, two more generations may ensue in such flowers as are produced. The numbers are, naturally, limited by scarcity of food, but they may prove important in attempts at control.

Such generations as do not hibernate we designate "short-cycle," while the larvæ which spin up for the winter we call "long-cycle."

Most of the long-cycle larvæ pass through the ginning process uninjured, and remain dormant until, at the next sowing time, they are sown in the fields along with the sound seed. As soon as the humidity is sufficient they come out of their silk-lined chambers, work their way to the surface by constructing a silk-lined tunnel, pupate within the tunnel, and ultimately, in the course of a few days, emerge from it to await the opportunity afforded by buds and flowers for the all-important purpose of ensuring the continuance of their race, with the incidental cost to the cultivators of a few crores of rupees.

The actual nature of the main damage done by the individual is that buds, flowers, and young bolls are completely destroyed; that in the older bolls a few to all the seeds in one lock are eaten out, so that either useless lint, or none, is produced; that one caterpillar may destroy some of the seeds in more than one lock, consequently damaging more lint; and that the quality of lint, oil-content, and germination power of unattacked seeds in the boll are often adversely affected.

In the United Provinces the cultivators' estimates of the loss from the Pink Boll-worm is two to eight or more annas according to locality and season. As ten annas is said to be a good average crop, this would mean approximately fifteen to a hundred or more per cent. over the harvested crop. My own experiments this year substantiate the enormous amount of damage done. I consider that an average loss of 25 per cent. is a conservative estimate. Now, the United Provinces, which is by no means the largest cotton-growing area affected by the Pink Boll-worm, is estimated to produce about eighty million pounds of cotton. This means that over twenty-five million pounds which ought to come to maturity fail to reach the market. These are, of course, round figures, still requiring definite proof; but add to them the damage caused in the Punjab and other cotton-growing areas in North India. Then, even if this is a considerable over-estimate of the loss, the total will

still be a colossal figure, and it will be appreciated that any measures which will effect the saving of all or most of the crop now lost will add materially to the wealth and well-being of the country. The problem is, how this is to be accomplished. It is obvious that none of the measures suggested for the Spotted Boll-worm will apply, excepting the clearing up of fields between seasons. The effective concealment practised by the larva and the moth precludes hand-picking operations, and renders poisoning ineffective. The adults are only slightly attracted to light-traps, nor do parasitic insects give us any reason to expect much help from them. Parasites of *Platyedra gossypiella* are scarce in India, and, as the insect is probably indigenous, there is not much likelihood of finding any effective ones elsewhere to import. Operations during the cotton season, thus, do not offer much hope. Where, then, is hope to be found ?

I suggested earlier that the insect had perhaps carried its cleverness too far. When it adopted the habit of shutting itself up for the off-season inside the hollow shells which, but for its mischievous activity, would have furnished food for beast and clothing for man, it may, perhaps, have delivered itself into the hand of the avenger. There, in the mass of seed, is the bulk of the next season's potential pest, and by suitable means of treating the seed, all the hibernating host can be destroyed.

This is the obvious solution. It has been seized in other countries to which the Pink Boll-worm has penetrated from India. It may prove to be the, and the only, solution of the problem for India. It is, however, a matter entailing vast outlay and organization, and the scheme for putting it into operation is not one lightly to be put forward. It must be backed by incontestable experimental evidence, and proof of its absolute efficiency, before its acceptance is conceivable or even desirable.

We know that by heating the seed to a certain temperature the larvæ can be killed without injuring the seed. There may perhaps be other and better methods, but this has proved effective, and capable of being carried out in ginneries. But to be of much use, the treatment should be universal. This means that all cotton seed

throughout North India would have to be dealt with—a formidable, but by no means hopeless proposition. But before such can be attempted there is much experiment to be carried out, and much definite knowledge to be sought. The causes which may affect the success of the method must be explored, such as the quantity and effect of hibernating larvæ in bolls dropped in the fields and the carry-over of short-cycle and long-cycle larvæ on alternative food-plants; the actual value of the damage done by the Pink Boll-worm, and the additional return from pest-free crops must be determined; and the feasibility of any method proposed for dealing with the infected seed must be clearly demonstrated.

An examination of these and other aspects of the problem is being conducted in Cawnpore by the Entomological Staff of the Agricultural Department of the United Provinces, with the co-operation of the Indian Central Cotton Committee. It is hoped that the investigation will result in means of controlling Boll-worm attack in North India, so ensuring to the cultivator the fruits of his labour, and to the country an increase in output and wealth, while calling, on the one hand, for no added toil, save that involved in the happy task of harvesting a full crop, and on the other, for no corresponding increase in area devoted to the crop.

It must, however, be remembered that scientific work frequently produces negative results, valuable from an academic view-point, but disappointing to the economic worker whose main interest is, of necessity, in attaining results of practical application.

The outcome of the enquiry is in the lap of the morrow. It is yet too early to offer any forecast of its results. There is much to be done before we shall know whether our hope will be realized; but the indications at present are such as to warrant very considerable hope of satisfactory and practical results.

A PRELIMINARY NOTE TO THE STUDY OF FIXATION OF AMMONIA IN SOUTH INDIAN SOILS.*

BY

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In their preliminary note[1] on the decomposition of calcium cyanamide in South Indian soils, Norris, Viswanath and Ramaswami Ayyar have observed that the decomposition of cyanamide in the soil is very rapid up to the urea and ammonia stages, the oxidation of ammonia to nitrates proceeding more slowly. Since nitrification proceeds at this slow rate, there is little danger of all the nitrogen becoming available too quickly, before it can be utilized by the crop. In the case of paddy soils, however, the conversion of the cyanamide nitrogen into ammoniacal nitrogen is very rapid, and it has not been possible to say exactly how the ammoniacal nitrogen is assimilated by the plant.

As a preliminary step to study this problem, particularly in the absence of information as to the form in which ammonia is liberated, it has been found necessary to study the capacity of the soil to fix ammonia from solutions of its various salts. Three lots of 100 grm. each of paddy soil from the Central Farm, Coimbatore, were shaken for one minute and allowed to stand for one hour with 250 c.c. each of solutions containing 19·88, 26·24 and 37·0 mg. of ammoniacal nitrogen in the form of ammonium hydroxide, carbonate and sulphate respectively. At the end of one hour these were filtered and ammonia was determined in the

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* Paper read at the Agricultural Section, Indian Science Congress, Bangalore, 1924.

[1] *Mem. Dept. Agri. Ind., Chem. Ser.*, Vol. VII, No. 3.

aliquots of the filtrate with the following results, as tabulated in Table I.

TABLE I.

Showing the amount of nitrogen fixed by 100 *grm. of paddy soil from solutions of ammonium hydroxide, carbonate and sulphate.*

Solutions	Amount of nitrogen added	Amount of nitrogen recovered	Amount of nitrogen fixed	Percentage of nitrogen fixed on the added amount
	mg.	mg.	mg.	
Ammonium hydroxide ..	19·88	0·84	19·04	95·8
Ammonium carbonate ..	26·24	2·80	23·44	89·1
Ammonium sulphate	37·00	6·91	30·09	81·4

This preliminary experiment shows that the soil experimented with here is capable of fixing ammonia in any of the three forms given, and that the amount fixed is many times more than what will be available under any conditions of agricultural practice. The next point for investigation is the mechanism and range of fixation.

The problem of fixation by soils has received considerable attention for some time and quite a large volume of literature has developed on the subject. But the amount of work done in this direction on swamp soils is very meagre, if not practically nothing. The problem of ammonification and fixation of ammonia with special reference to paddy soils has, therefore, been taken up for study and the aspect of fixation is being considered first.

It has been held that the extent of fixation by soils is related to their agricultural value and that the greater the capacity of the soil to fix, the better it is suited for agricultural purposes. It has also been known that the process of fixation is generally, if not invariably, attended with base exchange, so that, while certain plant foods are held in a state of absorption by the soil for subsequent use, certain others are disengaged from the soil and made available

for the plant. In view of the importance of changes that take place when fertilizer salts are added to a soil, as in ordinary agricultural practices, and in view of the different types of soils existing in this presidency, this investigation has been extended to the different classes of soils and the results presented herein are some of the preliminary observations of the behaviour of ammonium sulphate on these different classes of soils.

It is realized that, from a chemical point of view, the manuring of a soil is an independent individual proposition, requiring a careful study of individual conditions. There is likely to be variation in the behaviour of a fertilizer with the different classes of soils and with different soils of a similar class. Such instances are not wanting in the vast mass of literature that has accumulated on the subject. However, there can be no denying the fact that the knowledge obtained from the behaviour of a particular class of salts towards specific types of soils cannot fail to be of a reliable guide in judging, in a general way, the manurial requirements of soils of a given type, particularly in a country like this where experimental work on soils is not far advanced.

Based on agricultural practices and natural conditions, the soils of this presidency can be divided into four main classes. They are (1) paddy soils, (2) garden soils, (3) black soils and (4) estate soils (planting districts).

(1) Paddy soils are essentially rice soils and the cultivation and cropping is always under submerged conditions.

(2) Garden soils are usually red soils under irrigation.

(3) Black soils are dry soils, dark in colour, containing proportionately larger amounts of lime and depending principally on rain.

(4) Estate soils are laterite soils from highlands with a heavy rainfall, are usually lighter than the other types and are characterized by their high content of iron and alumina and organic matter and very low lime content.

These four principal types of soils have been experimented with, and the pH values and the chemical and mechanical analyses of these four soils are given below in Table II.

TABLE II.

Chemical analysis.

Constituents	Paddy soil	Garden soil	Black soil	Estate soil
	%	%	%	%
Insoluble mineral matter	75·01	79·04	78·50	52·96
Iron oxide (Fe_2O_3)	5·39	4·73	3·06	29·73
Alumina (Al_2O_3)	10·16	6·68	7·06	
Lime (CaO)	1·01	1·50	3·67	0·06
Magnesia (MgO)	1·47	0·92	1·49	0·12
Potash (K_2O)	0·50	0·53	0·39	0·34
Soda (Na_2O)	..	0·12	0·18	..
Carbonic acid (CO_2)	..	0·54	1·30	..
Phosphoric acid (P_2O_5)	0·07	0·115	0·05	0·12
Sulphuric acid (SO_3)	..	0·03	Trace	0·42
Loss on ignition	5·14	5·79	4·30	16·01
Containing :—				
Nitrogen (N)	0·045	0·057	0·034	0·240
Available P_2O_5	0·011	0·036	0·015	0·0075
Available K_2O	0·010	0·018	0·003	0·013
Mechanical analysis.				
Fine gravel	3·55	6·30	9·50	..
Coarse sand	20·09	17·40	25·00	26·35
Fine sand	27·77	19·10	15·10	14·38
Silt	11·52	6·50	6·40	14·49
Fine silt	26·04	21·10	28·10	17·97
Clay	7·26	25·70	12·00	6·92
pH values	8·50	8·1–8·3	8·3–8·5	7·0

The paddy, garden and black soils were obtained from the Central Farm, Coimbatore, and the estate soil is a composite of eight

soils received from Nallatanni Estate, Munar, Periakulam, for analysis, in the laboratory of the Government Agricultural Chemist, Coimbatore. All these soils were dried in air and passed through 1 mm. sieve.

100 grm. of soil were shaken with 250 c.c. of ammonium sulphate solution in a shaking bottle for a minute and allowed to remain for some time until equilibrium was established. At the end of this period the liquid was filtered through dry filter paper and the necessary determinations made. The determinations of the basic and acidic radicals were made by the usual methods obtaining in an agricultural laboratory, but a word has to be said about the determination of ammonia. There has been a large number of methods for the determination of ammonia in soils. The suitability of the various methods for our kind of work on ammonification is being investigated. It is felt that a critical consideration of these methods is necessary, where the soil *in situ* is used in experiments dealing with ammonification, but for the kind of work which is the subject matter of this paper the usual method has been considered sufficient. Accordingly the ammonia in the filtrate was determined by distilling it with 1 per cent. potassium hydroxide solution. All the figures given in the several tables here are the averages of two or more determinations.

The scope of enquiry is, for the present, limited to the following considerations :—

(1) Time factor for attaining equilibrium between the fixer and the fixed.

(2) The influence of concentration on fixation.

(3) The nature of fixation.

The time required for the attainment of equilibrium between 100 grm. of soil and 250 c.c. of ammonium sulphate solution containing 37 mg. of ammoniacal nitrogen, ranging between one minute and four hours, was first determined and the results are tabulated in Table III.

TABLE III.

Showing the amount of ammonia fixed during varying periods of fixation. Nitrogen added 37 mg.

Soil type	Immediate N fixed	15 minutes N fixed	30 minutes N fixed	One hour N fixed	Four hours N fixed
	mg.	mg.	mg.	mg.	mg.
Paddy	30·49	30·05	30·19	30·09	30·98
Garden	33·36	32·34	32·19	33·08	32·43
Black	31·26	31·96	32·24	32·10	31·54
Estate	13·85	12·78	15·16	13·90	14·27

It will be observed that all the ammonia added is not recovered and that the soils are able to fix all the ammonia they could at that concentration almost immediately, and any increase in the time factor does not result in increased fixation at that concentration. In all the soils except the estate soil, the amount of ammonia fixed is nearly the same. In the case of estate soil, however, the fixation is low and is nearly half that of the other soils. The lighter texture of the soil may account for this behaviour.

TABLE IV.

Showing the influence of concentration of the added ammonium salt on the extent of fixation. Period of fixation one hour.

Concentration of the ammonium sulphate solution in terms of N added	PADDY SOIL 100 GRM.		GARDEN SOIL 100 GRM.		BLACK SOIL 100 GRM.		ESTATE SOIL 100 GRM.	
	N fixed	% fixed	N fixed	% fixed	N fixed	% fixed	N fixed	% fixed
mg.	mg.		mg.		mg.		mg.	
37 ..	30·09	81·4	33·08	80·4	32·10	86·8	13·90	37·60
111 ..	75·02	67·6	87·16	78·5	82·16	74·0	24·20	21·80
222 ..	125·40	56·5	152·00	68·0	141·64	63·8	47·28	21·30
555 ..	238·25	42·9	308·95	55·7	294·25	53·0	109·10	19·70

From the above table it will be seen that, while the absolute amount of ammonia fixed increases with increase in concentration of the solution of ammonium sulphate, the percentage fixation on the added ammonia decreases. This increase in the absolute amount, or decrease in the percentage fixed, is not, however, in direct proportion to the increase in concentration. Nevertheless, a certain amount of uniformity is observed in the case of all soils in the amount fixed. For instance, when the concentration is trebled all the soils absorbed about two and a half times the original amount. Similarly when the concentration is increased fifteen times all the soils absorbed 8 to 9½ times the original amount.

As in the previous case, the fixation by estate soil is lower than that by the other soils and reaches the percentage constant earlier, i.e., at lower concentrations. If the percentages of ammonia fixed at various concentrations by the soils are plotted, the curve for the estate soil becomes almost a straight line even as early as at a concentration of 111 mg., whereas in the case of the other three soils it is not so.

From these two sets of experiments it will be seen that the soils may be said to fix ammonia in the following order:—Garden soil, Black soil, Paddy soil, Estate soil.

The results set out in Tables V and VI explain the nature of fixation. The liberation of bases is in proportion to the amount of ammonia fixed. This indicates that the process of fixation is essentially a chemical one. In all these experiments the chlorine and carbonic acid contents of the soils were not affected.

TABLE V.

Showing the equivalents of the different cations displaced.

100 *grm. of soil* plus 250 c.c. *ammonium sulphate solution* (37 *mg. N*).

NH_4 *added* 47·57 *mg.* SO_3 *added* 105·7 *mg.*

Soil type	Time of fixation—Immediate							Time of fixation—One hour						
	NH_4 fixed	Ca found in solution	Mg found in solution	K found in solution	Na calculated from balance of SO_3	SO_3 found in solution	NH_4 equivalent of Ca, Mg, K & Na	NH_4 fixed	Ca found in solution	Mg found in solution	K found in solution	Na calculated from balance of SO_3	SO_3 found in solution	NH_4 equivalent of Ca, Mg, K & Na
	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
Paddy ..	39·2	15·0	3·7	..	25·1	104·6	39·1	38·7	18·9	4·2	..	18·8	103·3	38·0
Garden ..	42·9	7·1	2·8	..	37·5	99·2 ?	39·9 ?	42·5	10·0	3·8	..	35·8	106·7	42·5
Black ..	40·2	17·9	3·0	..	25·4	106·3	40·5	41·3	19·6	3·9	..	21·9	104·3	40·7
Estate ..	17·9	7·1	0·5	..	1·1	85·4	7·0	17·9	8·0	0·5	2·1	..	82·0	9·0

TABLE VI.

Showing the equivalents of the different cations displaced.
NH_4 added 713·57 *mg.* *SO_3 added* 1585·5 *mg.*
Time of fixation one hour.

Soil type	NH_4 fixed	Ca found in solution	Mg found in solution	K found in solution	Na calculated from balance of SO_3	SO_3 found in solution	NH_4 equivalent of Ca, Mg, K & Na
	mg.	mg.	mg.	mg.	mg.	mg.	mg.
Paddy	306·3	155·7	43·7	8·8	120·4	1579·7	303·8
Garden	397·3	189·3	59·3	17·8	160·8	1579·4	393·6
Black	378·3	247·0	40·1	..	117·9	1577·8	374·8
Estate	140·3	35·1	5·4	5·3	64·2	1479·2	89·3

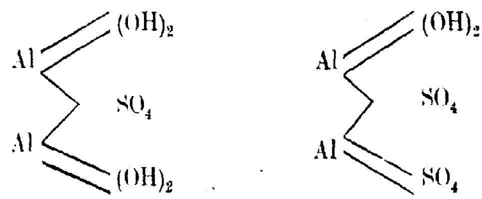
The balance of sulphuric acid (SO_3), after combining with NH_4, Ca, Mg and K, found in solution, is put down to soda on the analogy of combination of acids and bases in water analysis. It will be seen that the ammonium equivalent of Ca, Mg, K and Na equals the amount of ammonium fixed in the case of paddy, garden and black soils. In the case of the estate soil, however, a deficiency occurs and from Table VI it will be observed that 51 mg. of NH_4 and 106 mg. of SO_3 have to be accounted for. Experiments with iron alum and sodium sulphate have also shown that the sulphuric acid from these salts is held back by the estate soil. Similar results were obtained with phosphates also.

It may be that a portion of the ammonium radical equivalent to the SO_3 available is held up as ammonium sulphate by the soil or that the ammonium and the sulphate radicals are entirely in separate combinations. The latter view seems more probable from a knowledge of the agricultural behaviour of the estate soils.

The pH value of the estate soil indicates neutrality or at best a slight tendency towards acidity, and it is surprising that a soil with

a tendency to be acidic shows selective absorption (adsorption ?) towards acid ions.

It will be seen from the table of analysis (Table II) that this soil is very poor in lime and available phosphoric acid with a high content of iron and alumina and organic matter. It is probable that on the addition of ammonium sulphate to the soil, the acid radical, in the absence of lime, combines with the hydrosols of iron and alumina to form insoluble basic sulphates of the types



or double sulphates which are comparatively less soluble. Similarly when a phosphate is added the phosphate ion combines to form the insoluble phosphates of iron and alumina.

From a practical point of view, the indications of the evidence before us are that it is not advisable to apply a soluble phosphate like superphosphate before the application of lime to the soil, as in that case the phosphoric acid is all in combination with iron and alumina which may not be so quickly and easily available to the plant, even if lime is subsequently added. In fact, laboratory experiments have shown that liming did not disengage, in appreciable amounts, the phosphoric acid absorbed. Even if the phosphoric acid combined with aluminium is made subsequently available for the plant, there is always the risk of the hydrosols of these metals inducing a state of pseudo-acidity exerting their undesraible influences on the soil and on the plant. If, on the other hand, liming precedes the application of a phosphatic manure, the aluminium hydrosols are suppressed and the phosphoric acid can then go into combination with lime in which form the phosphoric acid is made more easily available to the plant. The evidence also points out that soluble phosphates like superphosphates applied alone may not be as effective as basic phosphates of lime.

CONCLUSIONS.

1. The soils of the Central Farm, Coimbatore, for instance, the paddy, garden and black soils, have a high absorptive power. The estate soil has a very low absorptive power.

2. The process of absorption is almost instantaneous.

3. The absolute amounts fixed by these soils increase with the increase in concentrations of ammoniacal solution used, while the percentage fixed on the added amount decreases and tends to reach a limit. In the case of the estate soil this limit has already been reached even at lower concentrations.

4. Consequent on the fixation there is a displacement of other cations from the soils. The chlorine and carbonic acid contents are not affected.

5. In the case of the estate soils all the anions (SO_3) added could not be recovered.

6. The NH_4 equivalents of Ca, Mg and K found in solution after treatment with the soil do not agree with the NH_4 fixed by the soil, but the difference so observed always equals the NH_4 equivalent of the balance of SO_3 found in solution, after combining with Ca, Mg and K.

7. When calculated to Na, as is done in this work, the sum of the several sulphates found in solution agrees closely with the total solids estimated.

8. When a higher concentration of ammonium sulphate solution is used, potassium is displaced in the soil.

9. The abnormal behaviour of the estate soil when compared with the other soils in holding back large amounts of acid radicals appears to be connected with the large amounts of iron and alumina and low amounts of lime present in the soil.

Before closing I must express myt hanks to M.R.Ry. B. Viswanath Garu, F.I.C., Offg. Government Agricultural Chemist, Coimbatore, for the very kind help, advice and encouragement accorded to me throughout this investigation.

SEASONAL VARIATION IN PADDY.

BY

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AND

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Assistants.

The experiments concerned in this paper are the results of the study of seasonal variation in paddy plants with special reference to their flowering, tillering, length of straw and yield of crop for three consecutive years from 1920 to 1922.

As it is often desirable to express the degree of variability in exact mathematical terms, the writers have drawn a number of biometrical curves for three years separately of which each curve shows the seasonal variation among the individuals in the two particular classes of paddy, viz., the Sail and Broadcast Aus. The results have been calculated from a set of average variables in each individual group.

The experiments were carried on in $10' \times 10'$ plots where each variety was observed in regard to their respective flowering, tillering, length of straw and yield. 162 varieties of Sail and 56 varieties of Aus were taken for experiment on average. The season of sowing the seed-bed in the case ot Aus comes in April and May, while that of Sail in June and July according to the favourable rainfall. The

rainy season extends from March to October with an average precipitation of 135″ per year at the Karimganj Farm, as is shown in the curves of Fig. 5. It may be mentioned here that the paddy farm at Karimganj, where the experiments were tried, is situated in an inundated area which is a typical Surma Valley paddy land of clay soil.

There is some relation between the yield and the flowering, tillering and length of straw of paddy. How much relation there exists between them will be pointed out later in detail from the tables and curves.

Variation in flowering.

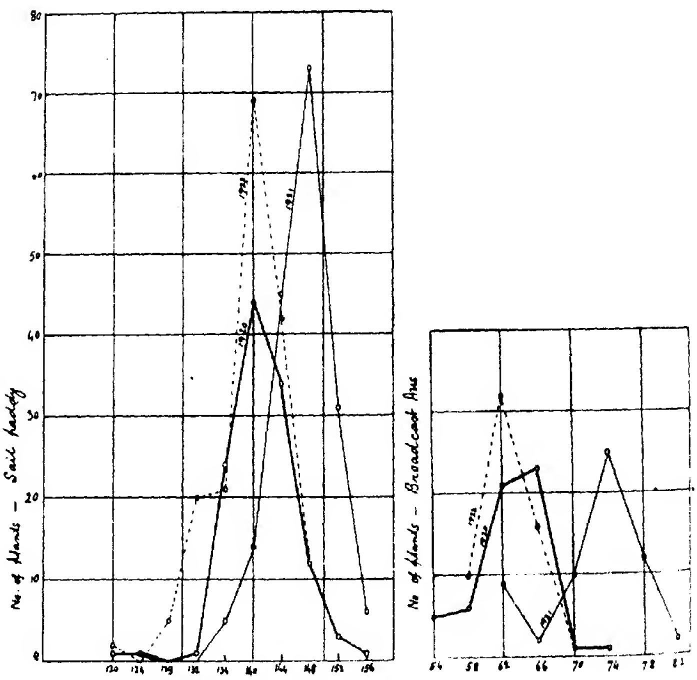
The Sail varieties flower every year at a particular time between the months of October and November irrespective of their date of sowing. This system of flowering in Sail may be taken as timely fixed. It is for this reason that the number of days from sowing to flowering in Sail directly varies with the date of sowing as the time of flowering is almost fixed. For example, a variety sown either on the 1st June or on the 1st July will approximately flower at the same time from the 15th to the 20th October.

Table I.

Showing the mode, mean and coefficient of variability and percentages of error in flowering of Sail and Aus paddies.

	Year	No. of varieties	Mode	Mean	Coefficient of variability in percentage
1. Flowering of Sail ..	1920	121	140	141·2	3·5 (± 0·15)
	1921	175	148	146·8	3·06 (± 0·11)
	1922	171	140	139·5	3·7 (± 0·13)
2. Flowering of Aus ..	1920	57	66	62·8	6·5 (± 0·41)
	1921	60	74	72·3	7·4 (± 0·45)
	1922	59	62	63·2	4·5 (± 0·28)

It may be pointed out here that in Table I there is some variation in the mean of the flowering in Sail, viz., 141·2, 146·8 and 139·5 in 1920, 1921, 1922 respectively. This is due to the fact that sowing was earliest in 1921 and latest in 1922. The difference in the number of days of the three means quite agrees with the difference in the number of days in the sowing time of the three years.



Number of days from sowing to flowering.

FIG. 1. Curves showing the number of days from sowing to flowering in Sail and Aus paddies for the years 1920–1922.

On the other hand, the time of flowering for Aus is rather periodic, i.e., they will flower in a definite length of time more or less irrespective of their date of sowing. This system of flowering in Aus may be taken as periodically fixed. The number of days from sowing to flowering does not vary with the date of sowing

but it may vary with the climatic condition. For instance, a variety sown in April or May will necessarily flower after a period of two months or so under normal conditions. But it may flower early owing to drought or late in case heavy rains and floods intervene.

Table I and the curves in Fig. 1 show clearly the variation in mode, mean, coefficient of variability and the calculated percentages of error in the experiment. In 1921 it is noted that the mean in Aus is 72·3, which is much greater than those of other two years. This excess of variation in the mean is due to excessive rainfall, as is shown in Fig. 5, and the subsequent flood.

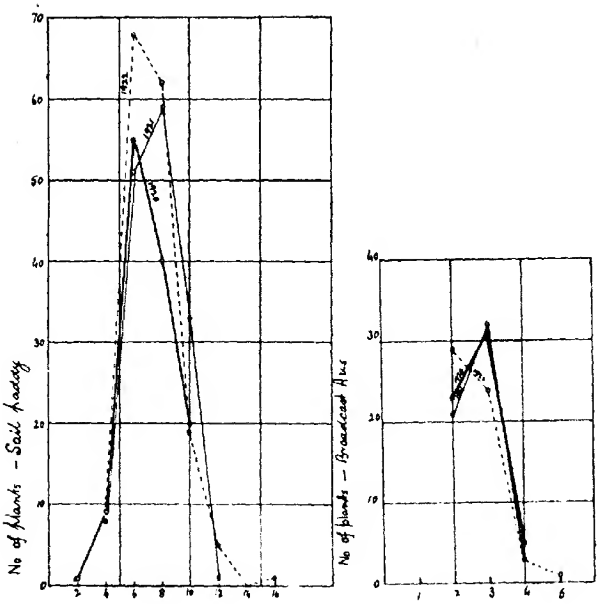
Here we find a relation between the early and late flowering of both Sail and Aus and their respective yield in *chhataks*.* In the case of Sail the majority of the varieties which flowered late were found heavy yielders, while in the case of Aus no marked difference was noticed in early or late flowering, but an average calculation showed higher yield in favour of earliness. From this it may be assumed that Sail paddy flowering late and Aus paddy flowering early favour the yield.

Sometimes insect attack or flood causes improper flowering so as to decrease the yield to a large extent. Even the lack of adequate amount of rainfall causes a good many number of empty glumes.

VARIATION IN TILLERING.

Generally, Sail paddy tillers more than Aus. The tillering of Sail is almost three times as much as in Aus and so the yield which will be shown later. The variation in mode, mean and coefficient of variability is rather limited, as is shown in Table II and the curves in Fig. 2, and so is the percentage of error in each case. In majority of cases it is found that where tillering increases yield follows the same. It has also been noticed that some varieties having a large number of tillering have loose or short ears and in some there is a tendency to produce empty glumes both of which are detrimental to the cause of yield.

* 1 *chhatak* = 2 oz.



Number of tillers per plant (average of 10 plants).

FIG. 2. Curves showing the number of tillers per plant (average of 10 plants) in Sail and Aus paddies for the years 1920-1922.

TABLE II.

Showing the mode, mean and coefficient of variability and percentages of error in tillering of Sail and Aus paddies.

	Year	No. of varieties	Mode	Mean	Coefficient of variability in percentage
1. Tillering of Sail ..	1920	125	6	7·1	24·5 (± 1·11)
	1921	153	8	7·6	22·9 (± 0·93)
	1922	153	6	7·9	25·0 (± 1·02)
2. Tillering of Aus ..	1920	59	3	2·7	22·0 (± 1·42)
	1921	56	3	2·7	19·0 (± 1·21)
	1922	57	2	2·6	25·7 (± 1·73)

VARIATION IN LENGTH OF STRAW.

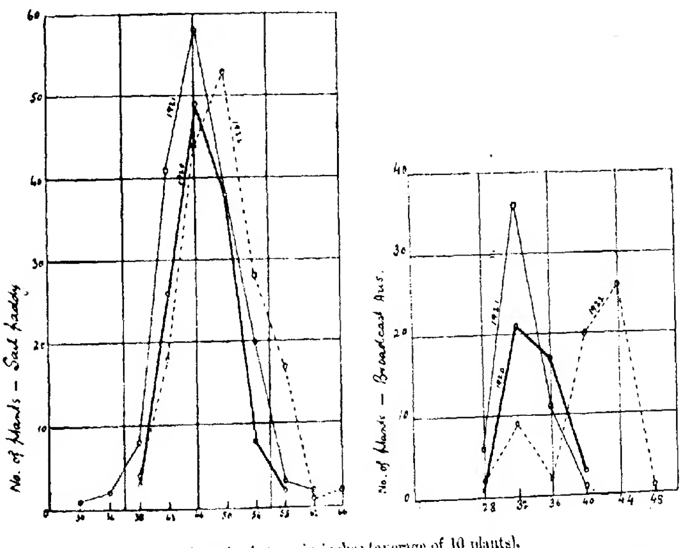
Length of straw mostly varies with the supply of water. Though usually one seldom expects any definite relation between the length of straw and yield, it has, however, been found by calculation that length of straw favours the yield in both Aus and Sail paddies.

TABLE III.

Showing the mode, mean, coefficient of variability and percentage of error in length of straw of Sail and Aus paddies.

	Year	No. of varieties	Mode	Mean	Coefficient of variability in percentage
1. Length of straw in Sail (in inches)	1920	126	46	46·9	8·3 (± 0·35)
	1921	173	46	46·6	10·3 (± 0·40)
	1922	167	50	49·5	10·3 (± 0·38)
2. Length of straw in Aus (in inches)	1920	42	32	34·1	7·6 (± 0·56)
	1921	54	32	32·5	7·3 (± 0·47)
	1922	60	44	40·1	11·9 (± 0·73)

From both Table III and the curves in Fig. 3 it is evident that there is a certain degree of variation in the length of straw in three successive years in their mode, mean and coefficient of variability.



Length of straw in inches (average of 10 plants).

FIG. 3. Curves showing the length of straw in inches (average of 10 plants) in Sail and Aus paddies for the years 1920–1922.

The percentage of error is also very small, as is shown in the table. Among the mean a great deal of variation is noticed in 1922 both in Sail and Aus. This is due to favourable rainfall, as is shown in Fig. 5.

Variation in yield.

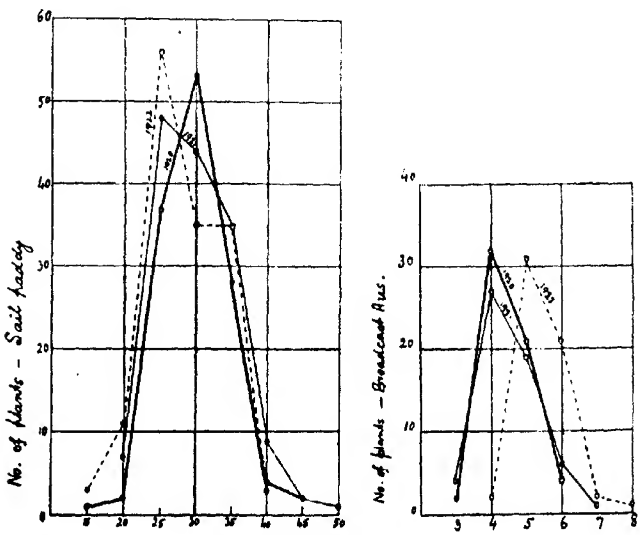
The yield of paddy usually depends on the normal vegetative growth and the normal distribution of rainfall, the latter of which is the most important. Although the yield varies from year to year its variation is limited both in Sail and Aus.

Table IV.

Showing the mode, mean, coefficient of variability and the percentage of error in the yield of Sail and Aus paddies.

	Year	No. of varieties	Mode	Mean	Coefficient of variability in percentage
1. Yield of Sail (in *chhataks*)	1920	127	30	29·9	15·6 (± 0·68)
	1921	146	25	30·0	18·5 (± 0·71)
	1922	143	25	28·4	18·5 (± 0·76)
2. Yield of Aus (in *chhataks*)	1920	59	4	4·5	14·9 (± 0·94)
	1921	57	4	4·5	18·7 (± 1·22)
	1922	57	5	5·5	12·7 (± 0·81)

In Table IV and the curves in Fig. 4 it is clearly shown that the mode in yield is between 25 and 30, and 4 and 5 *chhataks* in Sail



Yield in *chhataks* per 100 plants.

Fig. 4. Curves showing the yield in *chhataks* of Sail and Aus paddies for the years 1920-1922.

and Aus respectively on an average of 100 plants. The mean stands within a narrow limit and so is the coefficient of variability and the percentages of error which are between 15·6 (±0·68) per cent. and 18·5 (±0·76) per cent. respectively.

RELATION BETWEEN YIELD, FLOWERING, TILLERING AND LENGTH OF STRAW.

In order to show the relation of flowering, tillering and length of straw to the yield of crop in both Sail and Aus classes, a table has been drawn below on the basis of the high-yielding varieties on the right hand side of the yield curves corresponding to the varieties which have the largest number of days in flowering, the largest number of tillering and the longest straw in each class.

TABLE V.

Showing the relation between high yield and flowering, tillering and length of straw in Sail and Aus on the calculated average of three consecutive years from 1920 to 1922.

Flowering.

	Class of paddy	High yielding varieties	Early	Late	Ratio in favour of
1.	Sail	45	19	26	Late character 1 : 1·39
	Broadcast Aus ..	26	15	11	Early character 1 : 1·36

Tillering.

	Class of paddy	High yielding varieties	Light	Heavy	Ratio in favour of heavy tillers
2.	Sail	45	22	23	1 : 1·65
	Broadcast Aus ..	27	11	16	1 : 1·45

Length of straw.

	Class of paddy	High yielding varieties	Short	Long	Ratio in favour of long straw
3.	Sail	45	21	24	1 : 1·40
	Broadcast Aus ..	24	7	17	1 : 2·43

In considering the high yielding varieties which come on the right hand side of the curves of yield in both Sail and Aus from the arithmetical mean in each case, the ratio of high yielding varieties in relation to their early or late flowering, heavy or light tillering and short or long straw are clearly shown. From the table we

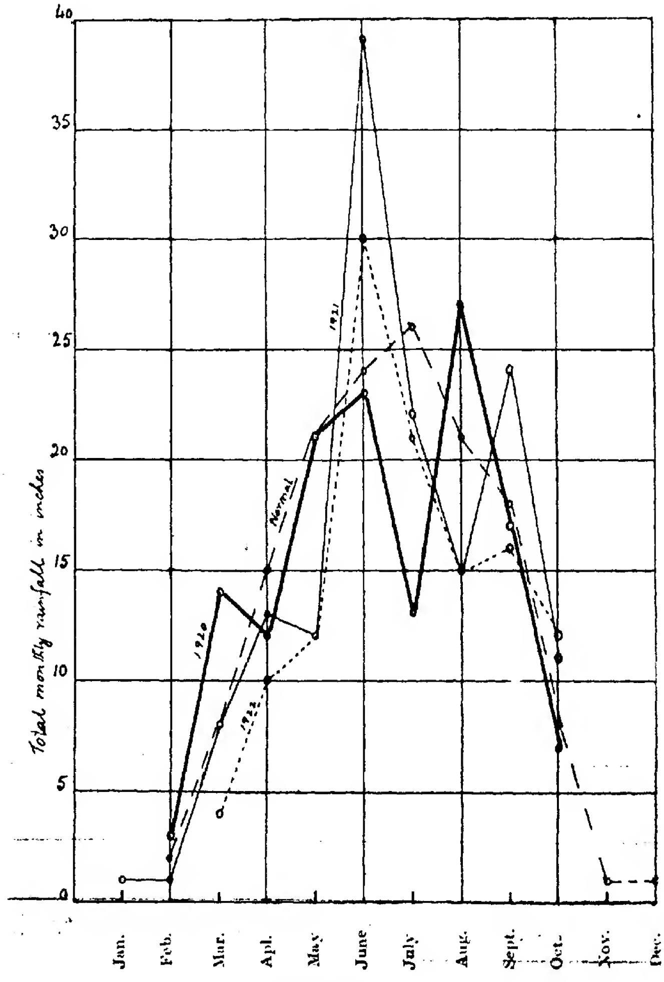


FIG. 5. Curves showing the total monthly rainfall in inches for the years 1920-1922 and the normal rainfall for the last 10 years at the Karimganj Farm.

find that in the case of flowering lateness in Sail and earliness in Aus have advantages to favourable yield in the ratio of 1 : 1·39 and 1 : 1·36 respectively. The tillering of Sail and Aus shows a corresponding ratio of yield in favour of heavy tillering by 1 : 1·65 and 1 : 1·45 respectively. Similarly the length of straw shows a ratio of yield to length by 1 : 1·40 and 1 : 2·43 in Sail and Aus respectively in favour of long straw.

It may be added here that in the rainfall curves in Fig. 5 attempt has been made to show the total monthly rainfall in inches at the Karimganj Farm for the years 1920, 1921 and 1922 with a normal rainfall curve which clearly shows the excess of precipitation for the years in question.

SUMMARY.

(1) The flowering of Sail is timely fixed, i.e., they flower in a fixed time of the year irrespective of the date of sowing, while that of Aus is periodically fixed, i.e., they flower after a certain period irrespective of the date of sowing.

(2) Other things being equal the seasonal variation in our cultivated plots is limited.

(3) Growth and yield of rice plants vary with the distribution of rainfall.

(4) Flowering, tillering, length of straw has a relation to yield.

RESEARCH WORK ON ANIMAL NUTRITION IN INDIA.*

BY

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UP to the present animal nutrition has not been scientifically studied in India. Accurate information regarding digestibility or nutritive values of Indian foodstuffs does not exist, there are no data to show either the requirements of Indian breeds or the effect of extreme seasonal climatic changes upon these requirements: very little is known concerning the distribution of vitamins in Indian foodstuffs and it is impossible to say how far the available proteid foods are deficient in essential amino acids.

These are some of the lines of enquiry along which fruitful results have been obtained in other countries and they can be expected to yield valuable information here too.

Indian conditions are, however, peculiar in many respects. It is, therefore, to be expected that other problems are likely to be quite as important here. For example, a study of the nutritive effect and proper utilization of very coarse fodders is a subject which probably deserves greater attention in India than it has received elsewhere. *In undertaking the study of animal nutrition in this* country, therefore, the first question which has to be faced is the selection from this unlimited field of enquiry of such lines of work as must be deemed of prime practical importance. When commencing work at Pusa four main lines of enquiry were selected, namely, (1) digestion coefficients, (2) nitrogen metabolism, (3) maintenance

* Paper read at the Agricultural Section, Indian Science Congress, Bangalore, 1924.

rations, and (4) digestion of coarse fodders. It is of interest to consider the reasons which led to the choice of these subjects.

1. *The determination of digestion coefficients of Indian foodstuffs.* Without a knowledge of the average digestibility of foodstuffs it is impossible to frame a ration on an accurate basis. We may feed definite amounts, but we have no notion how much nutritive material the animal is receiving, which is a hopeless proceeding. The following results obtained during some of our feeding trials will show the value of digestion coefficients.

	Nitrogen	Digestion
	Per cent.	Per cent.
A. Sample of gram	3·23	79·0
B. Sample of *chuni*	3·16	57·5

The nitrogen or proteid content of these two feeds is similar, but the amounts digested, or the nutritive values, differ considerably. The figures speak for themselves.

The determination of digestion coefficients is evidently an essential preliminary to further work. For this reason, and however great other claims might be, the Section must carry out digestion determinations continuously.

To appreciate our lamentable lack of information on this subject we have only to look at the bulky appendices of digestion coefficients contained in most American books on animal husbandry and dairy farming.

Owing to the fact that many of our foodstuffs are extremely variable in composition, discrimination is required if the work done is to be of general utility. On the whole, grains, pulses and other concentrates from mills are most uniform in composition and attention is being devoted mainly to these at present. The results obtained will undoubtedly be generally applicable.

However, we cannot get very far towards the goal of scientific feeding unless we possess, at the same time, digestion data for green fodders and for bulky sorghum, maize and millet fodders.

That these fodders are extremely variable in composition is well known. I have in this connection recently carried out a series of analyses of such typical fodders from different parts of India. The figures, which will be submitted for publication shortly, show the extent of variation that may be expected.

On account of the variable nature of these products it will not be an easy matter to procure the necessary digestion data; and in any case hearty co-operation is called for if we are to succeed. To attain the end in view two distinct lines of work have to be undertaken. Firstly, we must determine the limits of variation in chemical composition of these fodders in defined areas, and discover some correlation between seasonal and soil factors on these variations. This is a matter which can only be dealt with by local Departments of Agriculture.

Secondly, digestion determinations must be carried out with materials of different grade as judged chemically. This part of the work has been commenced at Pusa, and the results obtained will become progressively more valuable as information relating to the chemical composition of the fodders grown in different parts of the country accumulates.

The tremendous rôle these fodders play in India justifies the expenditure of a great deal of work on them.

Before passing on, one general remark regarding digestion coefficients is necessary. Digestion coefficients cannot reveal differences in quality depending upon the presence or absence of accessory factors which are imponderable to the chemist and can only be brought to light by biological methods. Work of this nature may become necessary in the near future; but it is certain that the spade work of digestibility determination must first make some progress to clear the way for more elaborate enquiries.

As a matter of fact, experience at Pusa shows that the long period digestion experiments initiated there are likely to be the most effective means of calling attention to deficiencies in accessory food factors.

2. *Nitrogen metabolism.* The most scarce and the most expensive food ingredient in India and the one which is at the same

time most essential for maintenance of bodily vigour as well as for flesh and milk production is the proteid or nitrogen-containing fraction of the ration.

If we are to utilize to the best advantage this expensive and essential part of the animal's food we must determine the proteid or nitrogen requirements of our breeds; we have to study the nitrogen economy of our animals; we have to find out the minimum amounts of nitrogen needed for simple maintenance as well for the production of work flesh and milk respectively; we have also to seek out optimum rations of the different available nitrogenous foods for these purposes.

In view of the great practical importance of these questions special efforts have been devoted to their study. The subject is undoubtedly a difficult one. We have found at Pusa that such factors as individual peculiarities, irritability of some animals when undergoing tests and climatic changes frequently cause appreciable variations in nitrogen metabolism. We are closely observing these variations for they must in time yield valuable information on fundamental distinctions between our breeds, on the extent to which the climatic factor influences nitrogen metabolism, on the relative efficiency of different proteids and lower nitrogen compounds, and on other important points. The scheme of work laid down is intended to collect data bearing on these questions.

For the present owing to the disturbing factors a considerable amount of work will have to be done to obtain results approximating to normal conditions.

All this work has been very greatly facilitated by, and much of it has only become possible through the use of a new form of nitrogen metabolism apparatus which was devised by me and set up at Pusa a year ago.[1] With the aid of this apparatus a whole series of nitrogen metabolism experiments was commenced. As soon as funds are available for the purpose, this work will be taken up at Bangalore on the lines already laid down.

Our experiments show that at times in some parts of the country the animals are wretchedly starved in respect to nitrogen

[1] *Agri. Jour. India*, XVIII, p. 267.

even when the rest of the ration is ample. In such cases the outgo of nitrogen from the body considerably exceeds the intake, the animals becoming emaciated and prone to disease. A little knowledge concerning the minimum necessary nitrogen ration would greatly improve matters.

A point deserving special attention is the following. When there is a nitrogen deficiency in the food the animal system exerts a powerful effort to conserve the body nitrogen. This fact is strikingly shown by the total amount of nitrogen excreted as well as by the form in which it is excreted. The following figures illustrating this effect were obtained at Pusa.

	Daily total nitrogen excretion	Per cent. of nitrogen excreted as	
		Creatin and Creatinin	Urea
	grm.		
Bullock receiving ample nitrogen ration ..	12·6	14	25·0
The same bullock receiving a deficient nitrogen ration	5·9	24	6·4

These figures have a very considerable physiological significance.

The primary result we require from the nitrogen metabolism work is information relating to the maintenance nitrogen ration, i.e., the amount of nitrogen which must be daily digested by an animal at rest to preserve its nitrogen equilibrium. The following striking figures obtained at Pusa show how this fundamental datum line is determined :

	Nitrogen intake (nitrogen digested) grm. per day	Nitrogen excreted grm. per day	Balance in grm. per day
First test	2·48	6·34	- 8·82
Second test	13·92	13·04	0·88

The figures show that the animal requires to digest somewhat less than 13·9 grammes nitrogen per day to maintain itself. It

should be stated here that the nitrogen maintenance ration for the particular food in question works out to about 34 grammes nitrogen (part being undigested), which shows that unless the fullest information is obtained nutrition data may be most misleading.

Another point to be observed is that a single short period test of the above nature might give entirely misleading results. This is due to the fact that when feeding is not altogether wrong the animal system is able to adjust its income and outgo of nitrogen to a wonderful extent and can maintain an approximate balance for a considerable time before it breaks down. Fortunately with the apparatus set up at Pusa and the scheme of work adopted there it is possible to carry out the tests over long periods. If this work can be continued at Bangalore we may, with confidence, expect to obtain significant results on this scientifically interesting and practically important question.

3. *Maintenance ration.* Passing from the nitrogen maintenance ration we come to the third subject of enquiry, namely, the complete maintenance ration. Figures for maintenance rations for cattle in India are urgently wanted; for even when digestion coefficients are known we can do nothing until the requirements of our Indian breeds have been ascertained.

To obtain more perfect knowledge on this subject elaborate apparatus will eventually be necessary. For the present we can obtain useful data by combining nitrogen metabolism determinations with digestion experiments, by suitably adjusting the food supply and by continuing the tests over long periods. This procedure was adopted at Pusa. The results obtained in some tests, which have been reported in the "Agricultural Journal of India" (Vol. XVIII, p. 459), were as follows: maintenance ration for a 1,000-lb. bullock—0·52 lb. protein, 6·5 lb. carbohydrate and 0·28 lb. fat.

These results are no more than a first approximation; they must be checked and elaborated by other tests on the same lines. Further work will no doubt prove the local (Bihar) bullock to be a very thirfty animal.

4. *Coarse fodders.* The fourth and last subject is concerned with the digestibility of coarse fodders. Only two aspects of this

question, which are of special importance, can be briefly alluded to here.

(*a*) The usual procedure in foodstuff analysis differentiates between crude fibre, the residue which is not attacked by chemical treatment, and the nitrogen-free extract which is completely dissolved by chemical means. It is well known that in some cases the chemically insoluble crude fibre is digested with greater facility than is the readily soluble nitrogen-free extract. In such instances, therefore, the chemical procedure has failed to differentiate clearly between digestible and indigestible constituents.

We have found that this failure of the chemical process is much more marked in our experiments with Indian fodders than in tests recorded from other countries.

To shed light on the discrepancies and hence to obtain a better understanding of the digestion capacities of our animals, we are studying in greater detail the digestion of the various carbohydrates contained in coarse fodders.

(*b*) The work of digestion of such coarse fodders is excessive. Some animals would certainly expend more energy on the digestion work than they could derive from the food digested —a process which is more wasteful to the system than simple starvation. Our task, therefore, is to find out the extent to which our breeds of cattle can avail themselves of these low forms of energy. It is worth observing that information on the potentialities of coarse foods would be specially useful in seasons of scarcity.

In such a brief statement of the case it is impossible to do justice to the importance of the subject. If, however, we take into account the fact that in no country in the world are cattle obliged to subsist on coarser material than they have to do in India, it will be admitted that we must consider this problem also to be one which concerns us specially.

This is a main outline of the work initiated at Pusa. Association with the dairy work at Bangalore will undoubtedly bring to the front nutrition problems connected with milk production and the growth of young stock.

THE CONTINUOUS GROWTH OF JAVA INDIGO IN PUSA SOIL.*

BY

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AND

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In previous publications,[1] including a paper read before the last meeting of the Agricultural Section of the Indian Science Congress (Lucknow, 1923), we have brought forward a good deal of evidence which bears on the theory of phosphatic depletion in the soils of North Bihar.

In 1919 and subsequent years, when the rainfall was scarcely more than sufficient for growth and when floods did not occur, Java indigo did well in Bihar. In 1919 for example, many of the Bihar estates, for the first time after many years, reaped an excellent second cut of indigo. The fact that good crops of indigo are obtained when a moderate and well distributed rainfall occurs without floods and the circumstance that poor yields are always obtained when excessive rainfall and floods are the rule are difficult to reconcile with a soil depletion theory. Such occurrences, however, readily fall in with the view that the real cause of the difficulties met with in Bihar is the water-logging of the pore-spaces. Further, a consideration of the general rural economy of the indigo tract, the fact that this region not only supports a dense population

* A paper read before the Agricultural Section of the Indian Science Congress, Bangalore, 1924.

[1] *Jour. of the Roy. Soc. of Arts*, LXVII, 1919, p. 762; *Mem. of the Dept. of Agri. in India (Botanical Series)*, XI, 1920, p. 1; *Agri. Jour. India*, XVIII, 1923, p. 148.

but also exports large quantities of oil seeds, tobacco, food grains and work cattle, and the circumstance that the cultivators never apply phosphates to their land, lend no general support to the view that this artificial manure is necessary.

Is it possible to design a simple and crucial experiment the results of which will finally decide this depletion theory? Direct field trials with superphosphate have not yielded definite results. Some other method of experiment, in which all disturbing factors can be removed, must, therefore, be devised. If we take a definite volume of the ordinary soil, including the sub-soil, of the tract in question, place it in a lysimeter provided with ample drainage and grow Java indigo continuously in the same soil without the addition of any phosphatic manure at any stage of the experiment, the yields obtained ought to show a progressive diminution if the natural supply of phosphate is a limiting factor. Such an experiment was started in June 1919 and has been continued till the present time. The area of the lysimeter was one-thousandth of an acre and the depth of soil 28·5 inches. The results are given in the following Table :—

TABLE I.

The continuous growth of Java indigo in Pusa soil.

Year	Details of treatment and yield	Total annual yield	
		s. ch.	
1919	June 23—Indigo sown .. .. Oct. 11—Crop cut, 8 s. 12 ch.	8 12	
1920	June 19—First cut, 4 s. 5 ch. .. .. Aug. 3—Second cut, 1 s. 5 ch. .. .. Oct. 31—Indigo resown	5 10	The lysimeter was not resown in October 1919.
1921	June 7—First cut, 11 s. 2 ch .. .. Aug. 2—Second cut, 7 s. 12 ch. .. .. Oct. 30—Indigo resown	18 14	

TABLE I.—*concld.*

Year	Details of treatment and yield	Total annual yield
1922	May 22—First cut, 5 s. 13 ch. .. .. July 8—Second cut, 3 s. 12 ch. .. Aug. 1—400 grammes (8 cwt. per acre) of sugar and 200 grammes (4 cwt. per acre) of sulphate of ammonia added to the surface soil .. Sep. 27—Third cut, 5 s. 12 ch. .. Sep. 27—Upper 9" of soil mixed with 200 grammes (4 cwt. per acre) of sugar and 750 grammes (15 cwt. per acre) of starch .. .. Sep. 29—Indigo resown	s. ch. 15 5
1923	May 9—First cut, 10 s. 12 ch. .. May 16—672 grammes (13 cwt. per acre) of starch added to surface soil .. July 8—Second cut, 8 s. 11 ch. .. 100 grammes (2 cwt. per acre) of ammonium sulphate added to the surface soil .. .. Oct. 1—Third cut, 4 s. 15 ch. .. Oct. 2—Indigo resown	24 6

It will be seen that not only has the yield not fallen off but it was actually higher in 1923 than in any previous year.

No change was observed in the character of the growth till July 1922—a year of heavy rainfall—when the permeability of the soil began to diminish and drainage became more difficult. In August 1922, the growth began to show all the signs of nitrogen starvation and the leaves turned yellow. The addition of sugar at the rate of 8 cwt. per acre and of sulphate of ammonia (4 cwt. to the acre) soon changed the colour of the leaves and also stimulated growth. The sugar was added to provide carbohydrate for the nitrogen-fixing bacteria. So rapid was the improvement that the third cut of 1922 was practically equal to the first. Sugar and starch were added to the surface soil before the lysimeter was resown in 1922. The starch provided a pure form of organic matter, free from phosphate, which could easily be incorporated with the soil. These materials stimulated growth considerably and also improved the texture of the soil. So rapid was the growth that a good deal of watering was needed in the hot weather and early rains of 1923. This, after a time, began to impair the permeability.

After the second cut on July 8th, the porosity of the soil began to fall off to such an extent that many of the old stumps did not form

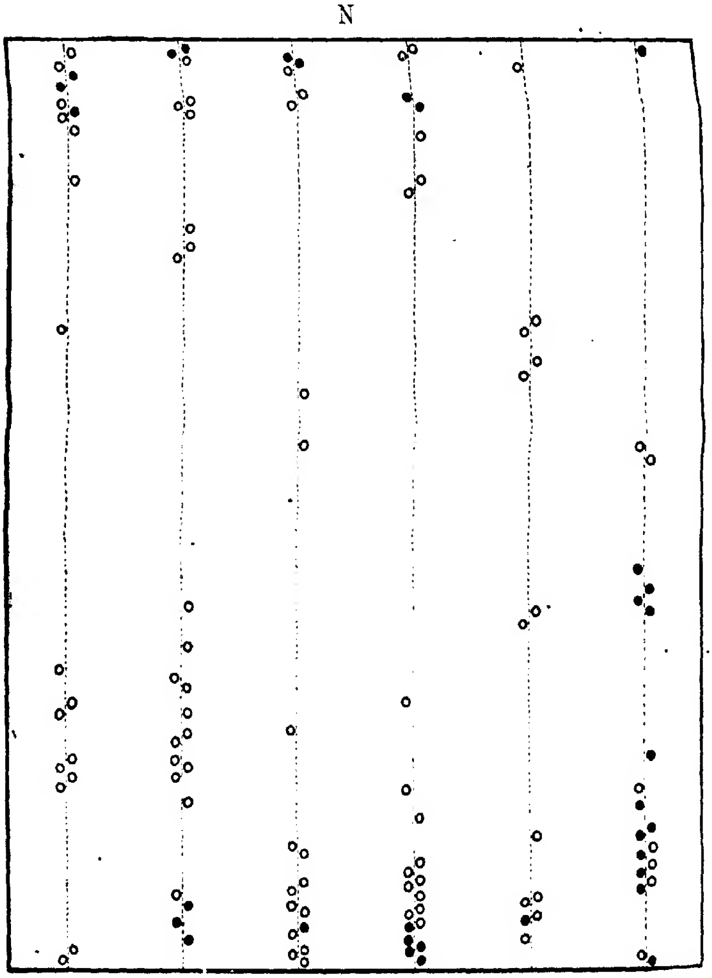

FIG. 1. Plan of continuous indigo plot (third cut of fifth crop). The largest plants are represented by black dots, the remainder by circles.

new growth. Those which survived were not distributed evenly over the lysimeter but occurred near the edge (Fig. 1) where aeration was improved by the contraction of the soil mass on drying. This

eft in several places a definite air space between the wall of the ysimeter and the soil. The best plants were nearest the edge. In the centre, none survived. In intermediate positions, the plants which grew did not do so well as those near the margin. These results are explicable on the basis of the water-logging of the pore-spaces but are difficult to understand on the theory of phosphatic depletion. As only a small number of plants contributed to the third cut, the yield in October 1923 was much higher than was expected. The average height of the plants was 57 cm. The sixth crop, sown on October 2nd last, is doing well and so far no signs of failure have been observed.

The yields obtained under these artificial conditions are remarkably high and exceed many of those obtained on the indigo estates. This is surprising considering the depth of soil available is only 28·5 inches, much less than that made use of by the ordinary crop. Further, no rotation is practised in the lysimeter and the land has no rest from indigo. The new crop is sown immediately the roots of its predecessor are picked out of the soil. The only cultivation, beyond surface cultivation, given to the lysimeter is the removal and immediate replacement of the soil just before sowing so that it can be thoroughly aerated. If the supply of phosphate in the Pusa soil is really deficient for the growth of indigo, how are these results possible? Five years' continuous cropping with indigo, without the addition of phosphate at any stage, ought to show a marked diminution of yield. On the contrary, the fertility is increasing now that a suitable method of improving the permeability and the content of organic matter has been adopted.

The only soil deficiency observed in this experiment has been loss of permeability followed closely by want of combined nitrogen. A shortage of nitrogen was expected as experience had taught us that Java indigo, although a leguminous plant, makes great demands on the nitrogen supply and rapidly impoverishes the soil. The difficulties in drainage were somewhat of a surprise as the soil used was above the average in porosity and good under-drainage was provided in the lysimeter. Loss of permeability is a serious factor in the rains as the pore-spaces then become suffused with water

and drainage stops. The soil assumes a wet, jelly-like condition, well known to the cultivators. The indigo plant rapidly reacts to the water-logging of the pore-spaces. Growth slows down, the active roots begin to show marked aerotropism and grow right up to the surface of the soil. The remainder soon die. When the old crop of the lysimeter is removed in October, the only active roots left are those in the upper inch of soil and those in the drainage layer at the base. No active roots occur in the intervening layers. This loss of permeability which, in all probability, is due to the formation of colloids, must very soon lead to a shortage of air in the pore-spaces and must profoundly modify both the flora and the chemistry of the soil. Is it possible by the addition of soluble salts or of substances like sulphur, which yields small quantities of dilute acid on oxidation, to prevent the formation of or to remove these colloidal substances? Preliminary experiments with sulphur and dilute sulphuric acid have markedly increased growth during the rains and have acted on the plant like dressings of nitrogenous manure.[1] The subject is one which might well repay further study not only on the alluvium but also on the black soils. It is not impossible that the results obtained with green manure and superphosphate during the rains are concerned with this question of soil colloids. It is well known that traces of acid have a profound influence on colloids. Superphosphate, when added to the highly calcareous soils of Bihar, rapidly reacts with the calcium carbonate present reverting to the insoluble calcium tri-phosphate. It not only acts as a dilute acid but also produces carbon dioxide as a by-product. Such a reaction might easily prevent the formation of or remove the colloids present. In doing so it would improve the aeration and the efficiency of the green manure. It is hoped that further work will be done on this subject and that no pains will be spared to work out a detailed explanation of this interesting case.[2]

[1] *Agri. Jour. India*, XVIII, 1923, p. 148.

[2] In 1923-24 in the Botanical Area at Pusa, the efficiency of green-manuring with *sanai* (*Crotalaria juncea* L.) was markedly improved by the addition of small quantities of sulphur (10 lb. to the acre). In the case of wheat and *sarson* (*Brassica campestris*) both the total weight of crop and the yield of seed was increased. The effect on the two crops was similar to that of a dressing of nitrogenous manure

SELF-STERILITY IN GRAPES.

BY

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Certain centres in the Bombay Deccan are among the most important locations of grape culture in India, and Nasik in particular has a very wide-spread reputation for the fruit which it produces. The variety usually cultivated there is known as *Bhokari*, and while this is one which yields well, it is by no means of the highest quality. Two other varieties are actually found grown at Nasik, known as *Phakadi* and *Pandhari-sahebi*, which give very much better grapes, but their yield is relatively so small that their cultivation cannot extend or become profitable.

The question has, therefore, been as to how to get rid of the shy-bearing character of these superior varieties. The matter has been under study for a number of years and certain results have already been obtained. Thus, for instance, Gole[1] at Nasik has had partial success in increasing the yield of *Phakadi* by grafting it on *Bhokari* stock. Prayag[2] claims that the yield has been substantially increased in the case of *Phakadi* by grafting it on *Bhokari* stock, by adopting an overhead system of training, and also by making modifications in the method of pruning. With regard to *Pandhari-sahebi*, experiments have been less in number. This has been due to the fact that though it is a far finer grape even than the *Phakadi*, it is a still poorer yielder than the latter. Of many methods of increasing the yield of *Pandhari-sahebi* tried by Prayag in 1919, the only one which really showed any promise was that of overhead training, but even in this case the average yield per plant was still very low.

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[1] *Agri. Jour. India*, Vol. XIV, Pt. I, p. 116.

[2] *Agri. Jour. India*, Vol. XVII, Pt. I, p. 41 ; *Poona Agri. Coll. Mag. Reprint* No. 16 (1921).

Now in the foreign grape-growing regions the same difficulty had frequently cropped up. An excellent grape has been found which refused to yield well in spite of every effort, and it was early suspected that it was caused by the self-sterility of the pollen of the particular variety. Thus, as far back as 1898, Beach[1] in New York came to the conclusion that while the amount of such sterility depends on climatic conditions, it does bear a definite relationship to the nature of the stamens in the flowers of the variety. It seemed, however, not to be due to the insufficient supply of pollen grains in the anthers. In the following year, work[2] at the same centre (New York) seemed to indicate that many varieties of grapes require crossing for the proper formation of the berries, and later, it was more than suspected that in some cases the cause of sterility was simply the impotency of pollen grains of many good types of grapes. Booth[3] connected the lack of fertility with the shape of the pollen grains and their arrangement in the mass. Again in 1915, Dorsey[4] was able to show a connection between the nature of the stamens and the sterility, and was also able, in the cases in question, to show that there were defects in the pollen grains themselves.

In view of these results and of the relative failure of all other methods in the case of the *Pandhari-sahebi* grape, a thorough examination of the types of grape grown at the Ganeshkhind Botanical Gardens, Kirkee, was undertaken, and it, at once, came to light that there is a close relationship between the length of the stamens and the length of the carpel, and that while, in the fertile varieties, the stamens are quite erect and at least equal in height to the stigma, in the sterile *Pandhari-sahebi*, the stamens are shorter than the stigma and reflexed as well.

In the fertile varieties, the normal and the average length of the stamens corresponds with the longitudinal diameter of the carpel. According to the variety, the filament was found to vary in length from one to three and a half millimetres ; while the

[1] *New York Agri. Expt. St. Bull.* 157, p. 397, 1898.
[2] *New York Agri. Expt. St. Bull.* 169, p. 331, 1899.
[3] *New York Agri. Expt. St. Bull.* 224, p. 291, 1902.
[4] *Jour. Heredity*, Vol. VI, p. 243, 1915

longitudinal diameter of the carpel measured from one and a half to three millimetres.

Again, the study of the way in which the flowers open shows probably the cause of the thinness of the bunch of grapes even in the *Phakadi* variety. In *Bhokari*, our heavy yielding type, the flower opens by the corolla-cap being gently pushed upwards, and the stamens are held in the cap just above the stigma thus assuring its complete pollination; while with the *Phakadi* grape, the corolla-cap is flung off violently and the stamens are driven away—to fertilize the neighbouring flowers or to shed the pollen.

It would appear, therefore, that the lack of yield of the *Pandhari-sahebi* grape in the Deccan is due to the fact that the construction and the opening of the flower are such as to prevent self-fertilization taking place, and the only way of obtaining the fruit of this fine variety will be to arrange for cross-fertilization with a type whose pollen is known to be fertile. Experiments have been made to test the accuracy of these assumptions in both 1922-23 and 1923-24 on a plantation of *Pandhari-sahebi* at Kirkee far away from any other grape garden.

In the first place, seven bunches of flowers were left to see what proportion would form berries. These bunches contained from 135–300 flowers each (average being 222). Not one of them formed a berry, though they were quite healthy. All, in fact, dropped about fifteen to twenty days later.

In the same plantation in 1922-23, four similar bunches of flowers were individually hand-pollinated with the pollen of the self-fertile *Kali-sahebi* with the following results :—

Bunch number	Number of flowers in the bunch	Number of berries set
1	249	106
2	?	81
3	167	64
4	200	85

Taking bunch numbers 1, 3 and 4, it would appear that 42 per ent. of the flowers formed berries. A similar result has been btained in 1923-24. Thirty-one bunches of flowers were taken nd were pollinated simply by brushing the flower of the fertile ariety on those of the *Pandhari-sahebi*. The pollination in each ase was effected between 9 a.m. and 6 p.m. and the success of he fertilization can be seen between fifty and sixty hours later.

The result was in every way satisfactory. All the bunches of grapes in all cases developed normally and were full, giving excellent unches of grapes of high quality.

We are now able to account for certain plants of *Pandhari-ahebi* variety giving a good crop both at Nasik and at Kirkee. n each case, these were found to be planted in close association vith a fertile type, so that vines of the two intermingled, or the ollen of the self-sterile variety was easily carried to the flower of *Pandhari-sahebi*, thus enormously increasing the chances of cross-ertilization. And there is, evidently, now no reason why the uperior type should not more widely extend. It grows well, and o secure a normal yield it is only necessary to mix the plants, n every group, with those of a fertile type, or even better, to ake the trouble to fertilize the bunches of flowers by hand with fertile type in the way described above.

The result we have obtained may have a still wider application than to the *Pandhari-sahebi* type in the Deccan. In every grape-growing area, there are excellent grapes which give little or no fruit. The cause may be similar to that found in the present case, and it may merely mean more adequate provision for cross-fertilization of the flowers, to convert these sterile grapes into types of high productive power.

Selected Articles

THE PART PLAYED BY BRITISH EMPIRE IN THE PRODUCTION OF RAW COTTON.*

BY

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THIS subject is one of the utmost importance to Great Britain, as the provision of new areas for increased supplies of cotton vitally concerns the future prosperity of our great cotton industry in this country. Much has been written about this problem in papers and pamphlets which the British Cotton Growing Association has issued from time to time, and in this paper I shall necessarily have to go over much of the ground again, but the subject is of sufficient interest to justify any repetition. It is hardly necessary to emphasize the vast economic importance of the cotton trade to the welfare of Great Britain; it is the largest manufacturing industry in the country, and it is therefore a matter of grave concern to manufacturers that additional sources of supply should be established over a wider area, in order to prevent, as far as possible, the occurrences of shortages in supplies of the raw material—whether brought about as a result of climatic conditions, insect pests, or the operations of speculators, etc. In normal times Great Britain requires for her own use over 4,000,000 bales; of this about 75 per cent. was obtained from the United States, the remainder chiefly from Egypt, Brazil and other foreign countries, and only a comparatively small proportion from within the Empire. Special attention must be drawn to the

* Reprinted from *Jour. Tex. Inst.*, XV, 6.

present position as regards the American supply, the insecurity of which is the danger with which we are confronted to-day. For one thing the crop from the United States has dwindled considerably in size, and secondly American manufacturers continue to take an increasing proportion of American cotton. There seems not the slightest doubt that the day is not very far distant when the United States will require the whole of its crop for its own mills—if the trend of recent years afford a true guide. Thirty years ago the United States' crop was about 7,000,000 bales, but as the world's demands were less it was sufficient to meet all requirements at a price of about one-third that of present-day prices and still to leave a considerable proportion for the following season. For the period 1901–1905 the average total commercial crop was 11,087,000 bales, out of which America herself consumed 36·2 per cent. For the 1921-22 season, out of a total commercial crop of 11,496,000 bales, she utilized 55 per cent. For the 1922-23 season, out of a total commercial crop of 11,091,000 bales, the percentage taken by American mills was almost 61½ per cent. It is this problem which has so seriously alarmed thoughtful students of the situation. Of course, during the past two years the cotton industry in this country has passed through a period of deep depression, and it is not surprising to find that the consumption of cotton has been somewhat reduced.

Attention has been repeatedly drawn to the grave damage done to the crop in the United States by the Boll-weevil. In 1912 it caused damage to the extent of 3·26 per cent. of the crop. In 1921 these figures had increased to 30·98 per cent. of damage. The menace of this pest cannot be over-emphasized, and the enormity of the damage may perhaps be better illustrated when it is mentioned that in 1921-22 the acreage under cotton was 31,678,000 and the resultant crop 8,375,000 bales. In 1922-23 the acreage under cotton was 34,016,000 and the resultant crop 10,338,000 bales. For the present season of 1923-24 the American farmers planted 39,224,000 acres, and the result is estimated to yield 10,200,000 bales. No certain remedy for the destruction of this dreaded pest has yet been discovered, although several partially successful

attempts have been made to keep it under. It inflicts special injury on the longer staple, because where the Boll-weevil is prevalent the tendency is to plant only early maturing cotton, which is short and generally unsuitable for fine counts. From this it seems certain that the shortage of American cotton is now likely to be constantly recurring if not a permanent difficulty. Then with regard to the Egyptian crop, we are also on the short side in quantity of production. Egyptian cotton fills a place in the British industry which American cotton cannot occupy. Before the war the Egyptian crop had reached a total of approximately 7,500,000 kantars.* During the war period it fell to under 5,000,000 on one occasion, but there was some improvement in 1920 and again last year. One of the principal factors in the diminished supply is the low yield per acre which is partly attributable to (a) the degeneration of the productive power of the soil due to several causes, and (b) the ravages of insect pests, chief amongst which is the Pink Boll-worm. Furthermore, during the war schemes for irrigation, drainage, reclamation of land, etc., had of necessity to be abandoned or suspended. Various attempts have been made to restrict the depredations of the Pink Boll-worm, but so far no absolutely efficacious remedy seems to have been found. During 1919 a Cotton Research Board was created. It is composed of Heads of Sections of the Ministry of Agriculture, assisted by various officials in other Ministries in the Egyptian Government. The Board's function briefly is—to advise the technical section of the Ministry of Agriculture; to co-ordinate scientific experiments; and, in addition, to ensure the maintenance and improvement of the quality and quantity of Egyptian cotton. Extensive laboratories have been staffed and equipped and many experiments started; in fact, much praise is due to the activities of the new organization which has devoted already much study to improving the yield and quality of Egyptian cotton. It is difficult in days such as these to say very much as to the course of prices, but if we eliminate the purely speculative

* 1 kantar=99·5 lb.

view, the trade position seems to be that annual and potential supply of the raw material is definitely inadequate for the requirements of the world. The demand for American cotton is proceeding to-day on a basis exceeding 12,500,000 bales, whereas taking the last three years the supply from America is 2,000,000 bales below this figure. There is no doubt that the future for cotton textiles is sound, because after all they form one of the cheapest forms of clothing, providing garments for the most backward and impoverished people of China, Africa, India, etc., who can only afford a comparatively small amount wherewith to purchase the cloth they use for clothing. If the material is dear they have to be content with a smaller quantity, and consequently the demand per head is proportionately less. Therefore the question of increased cotton supplies must be looked at from the broadest point of view, so that the manufacturing industry may be provided with ample supplies of the raw material at a reasonable price. This can only be brought about by developing to the fullest extent cotton-growing in all parts of the world and at any rate extensions of the cotton-growing area will of necessity have to be found outside the American cotton zone. For the moment it is sufficient to indicate that in the widely scattered lands under the British flag attempts have been made with most encouraging results, proving not only that there is adequate land to grow all the cotton Lancashire can use, but that cotton of an excellent grade and staple can be produced. The quantity grown in the Empire is small in comparison with Lancashire's total consumption, but the rate of progress so far achieved is greater than was the case in the early days of cotton-growing in the United States, and it has not been an easy task. One cannot get natives to grow cotton all at once. For example, in Northern Nigeria, Uganda and Nyasaland, railways had to be built and a great deal of time had to be devoted to the getting out of statistics and estimates for their construction. Then in those countries which had irrigation possibilities, as for example the Sudan, it was necessary to construct barrages and canals, etc. In connection with the problem of transport, I cannot emphasize the fact too deeply that this is the key to the whole scheme of successful and

permanent establishment of cotton-growing in Africa and, in fact, in all the other new or potential fields. At the moment progress is retarded by inadequate transport facilities, even in districts where the industry is of long standing. After this short sketch of the position to-day, I will now pass on to deal with the part our Colonies and Overseas Dominions have played in helping to augment the world's cotton supply, and will first of all deal with India, and would point out at the outset that in weighing up the possibilities for cotton in any country with adequate transport facilities the three most important factors to be determined are—(1) suitable soil; (2) suitable climatic conditions; and (3) sufficient labour.

India. India is already a large cotton-producing country, about five million bales of 400 lb. being produced in 1923. The area under cotton in 1922-23 was 21,792,000 acres, and the yield 5,075,000 bales of 400 lb. each. In 1923-24 the total area sown amounted to 22,941,000 acres, and the total estimated yield is 5,042,000 bales of 400 lb. This gives an average output per acre of 88 lb. of lint, as compared with 93 lb. for the previous year. The principal cotton-growing Provinces and States are—Bombay, Central Provinces and Berar, Hyderabad, Punjab, Madras, Central India, and the United Provinces. India consumes internally more than half her total crop and, further, more than half of her yarn production is counts of 20's and upwards, counts above 22's forming nearly 20 per cent. of her total production, and as this is the style of cotton approaching that suitable for our trade, I propose to deal with this quality only, which is estimated at 1,400,000 bales, over 1,200,000 bales of which is required for her own consumption, plus roughly about 200,000 bales for export, the bulk of which goes to Japan. Japan is India's best customer for cotton, purchasing between 1 million and 1½ million bales, five-sixths of which is very short staple cotton, unsuitable for the requirements of Lancashire. In order to assist in expediting the work of the provision of suitable seed for distribution and growing of improved cottons, the Government of the Punjab has obtained the assistance of the British Cotton Growing Association in the development of an area

of land at Khanewal for the growing of cotton by improved methods, and incidentally the provision of seed for the local farmers. This estate has an area of 7,300 acres. It is laid out in four villages, each with its own mosques and other institutions. The land is let in blocks of 25 acres to tenants, who must possess two yoke of oxen and have three working members in family. A tenant receives 50 per cent. of the proceeds of the crops grown. The project has attracted great interest and its methods are being copied. The principal varieties of cotton grown are the American types, 4F, 285F and a further improved type 289F. The great trouble in India is that although cotton is being produced nine months out of the twelve, owing to the variation of climate the actual growing season in all parts is a short one. In the rain-grown areas the rains are not always well distributed, and in the irrigated colonies in Northern India there are frosts, and these are mainly the reasons why the shorter and more quickly maturing varieties now being produced are so popular. Again, the native is very conservative and prefers to grow something of which he is sure, besides which he is not rich and cannot afford to take risks. This means that continual experiments are necessary to produce a plant which will mature fairly early, possess a longer staple, and give a yield comparing favourably with the local types. The most satisfactory districts for such developments are the canal colonies of the Punjab and Sind, and by careful selection and breeding the agricultural staff have already evolved types which are quite satisfactory as commencement. Another difficulty is that of seeing the grower receives a fair price for his better product, otherwise he is naturally discouraged and will revert to growing those cottons which give him less trouble and with the value of which he is better acquainted. India undoubtedly can produce large quantities of cotton of $1\frac{1}{16}$ in. to $1\frac{1}{8}$ in., the most promising areas being the Punjab and Sind. What is required to get the cotton is continued experiments by experts to produce still more prolific and yet early maturing varieties; further, to be in a position to deal with pests and disease as they appear, for it has generally been found that exotic types are less immune than the indigenous types. The grower also should receive a price more in

accord with the relative value of his better produce, and some effort must be made to prevent the mixing of American and Indian types at the ginnery. At the moment it is openly done without the knowledge that it is harmful in the extreme. India possesses an excellent agricultural staff, which has done valuable work in the improvement of all crops produced in that country. The Agricultural Service is, however, deserving of augmentation, but unfortunately like many other countries the aftermath of the great war has brought about many changes, and there is little hope of increasing the European staff; on the contrary, there is some considerable danger of decreasing it. Fortunately for the improvement of cotton-growing, the formation of the Indian Central Cotton Committee, which under the Indian Cotton Cess Act (XIV of 1923) was incorporated as a permanent body and its constitution laid down in the Act, is most opportune. It is presided over by the Agricultural Adviser to the Government of India, and comprises on the official side the Director-General of Commercial Intelligence, seven representatives of Local Governments, and four of Native States; on the business side it comprises nine persons nominated by commercial organizations, one representing the Empire Cotton Growing Corporation, four representing cotton-manufacturing or cotton-ginning industries in the Central Provinces, Madras, and the Punjab, and ten persons representing the cotton-growing industry in Madras, Bombay, the United Provinces, the Punjab and the Central Provinces. It receives its funds from a levy of four annas per bale on all cotton consumed in Indian mills and exported from India. The proceeds will be devoted chiefly to agricultural and technological research. Agricultural research is largely provided for by grants to Provincial Agricultural Departments for the undertaking of specific investigations beyond their ordinary activities. Provision for technological research will be made by the Committee under its own direct control. A scheme for the setting up of a miniature spinning plant which contains both ring and mule spindles, including combing machinery, has been developed, and the testing room is fully equipped with the most modern instruments.

The Sudan. This is an immense country—roughly half the size of India. There are fair prospects for growing cotton in the Dongola and Berber Provinces, but owing to the spare rainfall irrigation from the Nile is necessary, and the difficulty is that the water can only be utilized for certain months in the year, as it is required for Egypt. There are also good prospects for American cotton in the rainfall areas south at Senga, Renk and Roseires, but there are other larger propositions in the Sudan which are more certain and which can be more quickly developed by irrigation. The first in importance is a large tract of land south of Khartoum, between the White and Blue Niles, known as the Gezira Plain, which comprises an area of 3,000,000 to 4,000,000 acres which is capable of cultivation by irrigation. Although in appearance this plain looks absolutely flat, the land has a slight slope, giving it a well-defined fall from the Blue Nile in the east to the White Nile in the west, which simplifies the problem for both irrigation and drainage. The scheme for cotton-growing in the Gezira was initiated by the late Lord Kitchener, and an agreement was entered into with a strong group of capitalists to provide the money for the commercial part of developing the undertaking. This body is known as the Sudan Plantations Syndicate, and they have done remarkably valuable development work. The scheme is as follows:—The crops are pooled. The Government of the Sudan provides the land and water, for which it receives 35 per cent. of the gross value of the crops produced. The growers receive 40 per cent. of the same, and the Sudan Plantations Syndicate, who make the minor canals, plough the land, generally supervise the cultivation, provide ginning and storage facilities, and look after the marketing, gets 25 per cent. Operations were started by means of pumping stations erected on the Nile, first at Tayiba, later at Barakat, Hosh, and Wad el Nau, and as a result some 20,000 acres of land have been irrigated and now produce about 20,000 bales of 400 lb. each. The Makwar Dam, near Sennar, 1¾ miles in length, stretching across the Blue Nile, is now in course of construction by the Sudan Government, the consulting engineers being Messrs. Coode, Fitzmaurice, Wilson and Mitchell, and the contractors Messrs. S. Pearson and Son, Ltd. It

is expected to be completed by July 1925, when sufficient water will be available to irrigate 100,000 feddans,* providing from 80,000 to 100,000 bales of cotton. The quality of the cotton produced in the Gezira is Sakellarides, which compares most favourably with the best Egyptian types. An adverse factor which came to my notice when in the Sudan was the damage caused by insect pests. The Sudan, like Egypt, is free from the Boll-weevil; it does not suffer from the Pink Boll-worm to any great extent, but the country is not entirely free from other pests, one being the cotton Thrips, which injures the plant by feeding on the tissues of the leaves and bracts. Aphis is another pest also fairly common.

As previously stated, there are other propositions in the Sudan, but of a minor character—the chief being Kassala, Tokar and Gedaref.

Kassala is situated some 250 miles east of Khartoum. The rainfall here is about 20 inches and coincides with the inundations made by the river Gash, which rises as a result of the rains in Eritrea, Abyssinia, the boundary being only a few miles distant from Kassala. This river irrigates over a length of 60 miles, then loses itself in the desert. The soil at Kassala is exceedingly good, it has dark, rich, black clay, and where tested was from 9 to 12 feet deep. After the water from the Gash—which floods the land in June, July and August—has soaked into the soil, cotton is sown and after October there is no rain. Cotton here gives from 200 to 250 lb. of lint to the acre; the variety is Sakel, the same as is grown in Egypt, and the staple and quality are excellent. Transport was the missing factor, the cotton having to be sent on camel-back to Port Sudan or Suakin, a distance of 250 miles, and the increase of cotton production was limited only to the camels available for transport. A railway has now been built, and joins the present Port Sudan-Khartoum line at Thamiam, therefore we may shortly expect quite an important increase in the present production of 4,000 bales.

Finally Tokar, twenty miles from Trinkitat, on the Red Sea, is a somewhat similar proposition, the land here being irrigated

* 1 feddan = 1·038 acres.

by the river Baraka. The volume of water is not so large as the Gash, and it is doubtful if more than 50,000 feddans will be available for cotton until some scheme is devised for controlling the waters of the Baraka. A quantity of cotton is, however, grown and the quality is excellent.

West Africa. A great deal of money has been spent in endeavouring to develop the cotton-growing industry in our Colonies there, and although attempts were not successful in some cases, they have been in others. In Nigeria the Association's main efforts have been concentrated. The population of Nigeria is approximately 18¾ millions—larger than that of any British Dependency except India. The area is approximately 335,700 square miles. It is about half the size of the Cotton States of America. The inhabitants are good farmers and the land is closely and well cultivated, and the growing of cotton has been practised there for many years, spun and made into clothing for its inhabitants. The methods of cultivation practised by the natives themselves are the result of long experience, and whether they can be improved upon can only be demonstrated to them and justified adequately by practical proof that some other method is productive of better results. At first in Nigeria cotton plantations were started with American overseers, but these were not successful. The country is now divided into two separate parts known as the Northern Provinces and the Southern Provinces. It is not so much from the Southern as from the Northern Provinces that large results are looked for. In the former we have strong competition in palm oil, palm nuts, ground nuts and cocoa, but in the latter there is practically only ground nuts which go quite well as an alternative crop to cotton. Again, the Northern Province is out of the forest belt. To encourage the small native cultivators to take up the growing of cotton, it was essential that a market for their crop should be practically guaranteed; that is to say, the native should receive a definite price for his seed cotton when it was grown, and the British Cotton Growing Association guaranteed for twelve months ahead a fixed price, so that the grower when he planted his crop knew what he was going to get. This naturally was very big risk for the Association

to undertake, for although at times profits were made, at others heavy losses were incurred. All the ginning is in the hands of the Association, four large up-to-date pneumatic ginneries being in commission along the Lagos-Kano Railway at intervals of about 60 miles. In recent years determined efforts have been made by the Department of Agriculture, in co-operation with the Association, to improve the cotton coming from Nigeria; the Agricultural Department of the Northern Provinces successfully established a type from the American long-stapled variety, known as Allens. In 1914 the production of this type totalled 11 bales. Not only did this improved type of cotton yield a heavier crop than the indigenous variety, but it also commanded a better price on the Liverpool market, being worth about 150 points premium as against a discount of 100 points for the other. Consequently the Association always offers the native growers an enhanced price, with the result that this improved type is rapidly superseding the local variety, so that from 11 bales in 1914, 855 bales had been reached in 1918, 3,380 in 1920, 8,173 in 1922, and in 1923 the total had reached 12,221 bales. This year the result is estimated at 17,000 bales, a really fine achievement for the Agricultural Department. It seems safe now to predict steady progress in the Northern Provinces proportionately to the increase of transport facilities, the spread of the activities of the Agricultural Department and general progress of the country on modern economic lines.

In the Southern Provinces, however, the industry has a less sure foundation. The climatic conditions cannot, ordinarily, be regarded as favourable to the production of a high grade cotton. Attempts have been made to introduce an exotic type of cotton in the Southern Provinces, but have not yet met with any substantial success. In order to encourage the natives throughout the cotton-producing areas to take greater care in handling and picking their cotton, steps have been taken for all cotton to be graded by Government examiners, and a difference in price is made between Grade I and Grade II in both the improved and indigenous types. There is no doubt that in the course of time the steps which have been taken in this respect will prove beneficial and result in a general

improvement in the quality of the cotton. In Nigeria we possess a field which, with its population and suitable soil, is capable of becoming, next to India and the Sudan, one of the most important cotton propositions in the Empire, but this is not going to be brought about without an expenditure of money and energy, and for success it would appear that the following essentials are necessary—(1) The extension of the present railway system; the construction of light railways to act as feeders to the main or trunk line; and the improvement of roads suitable for motor and other vehicular traffic. (2) The agricultural staff to be largely augmented so that a number of centres may be established to serve as seed farms and as an object lesson to the local farmers.

Uganda. The Uganda Protectorate covers an area of approximately 110,300 square miles, including 16,169 square miles of water, and the population was last estimated to be 3,150,000. It is a blackman's country and here also cotton-growing is a native industry, the crop being produced by thousands of native peasants, European and Asiatic cultivation being negligible, and, speaking generally, this existing system of native cultivation would appear to be the best. The natives cultivate the crop on innumerable small plots, which in the aggregate amount to a considerable acreage. They have really taken to cotton in a wonderful way, the soil is remarkably fertile, and practically every native in the cotton-growing area cultivates his quarter-acre plot of cotton. The first record of cotton exports from Uganda was in 1904 when 54 bales were shipped. In 1908 the quantity was 4,000 bales; in 1914 42,000 bales, which was further increased in 1921 to 81,350 bales. For the current year the estimated acreage is 418,609 acres and a record crop of 100,000 bales is expected. It will thus be seen that it is from Uganda we are at present receiving the largest quantity and, for its class, the best cotton from any of the new fields. The quality is excellent and is of high standard, when marketed in a good clean condition. It has a staple of from $1\frac{1}{8}$ in. to $1\frac{3}{16}$ in., and compares with some of the best American. There are a large number of ginneries in the Protectorate owned by cotton-buying and ginning companies and private individuals.

The Association is also directly established in the principal buying centres. With cotton practically non-existent twenty years ago, it must be admitted that the result obtained in so short a period is most satisfactory; in fact, cotton has extended so rapidly that it now heads the list of exports, being about 80 per cent. of the total exports of the Protectorate, and reflects the greatest credit on the Agricultural Department and its officers. With improvements in transport, new districts will be opened up, and with a sufficiently large and up-to-date Agricultural Department to maintain the quality and supervise the distribution of seed, it is hopefully anticipated that half a million bales per annum will be produced in this Protectorate.

Nyasaland. The territory comprised in the Nyasaland Protectorate is a strip about 520 miles in length and varying between 50 to 100 miles in width. The area is roughly 40,000 square miles, or about one-third the area of the British Isles. The most southerly portion of the Protectorate is about 130 miles from the sea. The soil and climatic conditions are most suitable for the cultivation of cotton and tobacco—in fact, tobacco is cotton's chief competitor. Cotton is cultivated on the plantation principle. The British Central Africa Co., the A. L. Bruce Estates, Ltd., and James Dickie, amongst others, have large areas under this crop. In 1915 the acreage under cotton was about 29,500, but some reduction took place during the war period, largely due to cotton land being used for tobacco owing to the better price obtained. The yield per acre varies, but with proper care in the selection of land larger yields may be expected. Cotton is also grown by the natives as a native industry, and they in many cases produce good crops, and it has been recognized that what was wanted by these growers was a steady remunerative price instead of greatly fluctuating prices, so that the possibilities in the production of cotton could be proved. Nyasaland cotton generally is excellent in quality, silky, and from $1\frac{1}{8}$ in. to $1\frac{3}{16}$ in. in staple, but too much of the cotton is stained as a result of insect pests. Steps are now being taken with a view to combating these pests. The first recorded export of cotton from Nyasaland was in 1902. The crop in 1916 reached the highest

recorded figure of 3,462,000 lb. During the war the necessity for producing native foodstuffs for the local forces combined with the very high prices for tobacco caused many planters to abandon the cotton industry. The native cotton crop also received a check, but proofs are not wanting that renewed interest is being taken in the industry, and with the view of encouraging the production of cotton by the natives, the British Cotton Growing Association has entered into an agreement with the Local Government, under which the Association for a period of five years purchases all native cotton grown on Crown lands in certain districts at a price to be fixed annually. By this means it is hoped to give the native grower that stability of price without which it was felt that he would never be encouraged to persevere in his efforts. The utilization of agricultural implements and mechanical means of transport is releasing manual labour either for extended agricultural operations or for absorption into native industries. The construction of an extension of the railway from Luchenza station on the existing Chindio Blantyre Railway to the south end of Lake Nyasa is under consideration. The opening of the new Trans-Zambesia Railway between Beira and Muraca on the south bank of the Zambesi opposite Chindio, in July 1922, has already greatly facilitated transport to and from the Protectorate. Until a bridge is constructed across the Zambesi, connection with Chindio is effected by steam ferry. Boll-worm is mainly responsible for the very low yield per acre, but the matter is receiving the earnest attention of the local Agricultural Department. A "Cotton Pest" Act has been enacted and every cotton bush in the country, both European and native, must be uprooted and burnt before the end of November, and the results of these methods have been found very satisfactory.

Tanganyika Territory. Tanganyika Territory, which was formerly German East Africa, is a large tract of country of some 365,000 square miles, the population of the area under British mandatory rule being about 4,000,000. Before the war the Germans had devoted a great deal of attention to the development of cotton-growing. This country does not, however, possess one large uniform cotton zone, but a number of districts the conditions of

which are rather diverse, and each district requires to be treated separately. During the war period, and for a little time afterwards, the industry was allowed to lapse, but an agricultural staff was appointed as soon as practicable and is now at work. One of the districts which showed promise of success is that immediately south of Lake Victoria, known as Mwanza. The Association has erected two ginneries in this district, but the prospects are very uncertain, owing to transport and other difficulties. Of the other areas the principal ones are Morogoro, Kilwa and Lindi, and serious attempts are being made to foster the cultivation of cotton as a native industry. The 1921 crop in Tanganyika produced 7,327 bales, and that of 1922 6,276 bales. In that year there was an approximate increase of 25 per cent. in the acreage planted, but bad weather and pests caused an unfortunate fall in the yield. The estimate for the 1923 crop is 10,125 bales. The native producers have been encouraged to sell all the cotton grown by them and there is little local consumption. In addition to the native industry, cotton is now being grown on a number of estates under European management, either as a full-time or rotation crop, which might well lead to greater developments.

Kenya. The territories comprised under the name of Kenya Colony and Protectorate, until recently known as British East Africa Protectorate, consist of about 240,000 square miles. On the west the colony adjoins the Uganda Protectorate, and on the south the mandated Tanganyika Territory. The high prices ruling for cotton in 1919 and early in 1920 caused some attention to be given to cotton by European farmers, and a small acreage was planted on their estates along with other crops. In the Kavirondo and some of the other native reserves a large extension of the area under cotton was also made. In order to develop the agricultural resources and wealth of the colony, it is essential that native agriculture should be fostered, but in any circumstances progress must inevitably be comparatively slow, and to succeed in effecting a substantial improvement in native agricultural practice and an increasing production, a large number of instructors are required. Hitherto cotton-growing in Kenya Colony has not been a success, preference

being given to other crops. The local Government has now elaborated a certain policy of native development, and with an extension of the railway system, a vast acreage of native reserves and European owned land will be opened up.

Union of South Africa and Rhodesia. Since 1910 cotton has been exported from the Union of South Africa, but the quantity up to 1916 was not very large. In 1919 it was about 2,000 bales, and for the last season about 6,000 bales. Cotton is grown on plantations and on land owned by farmers, and not as a native industry. The chief centres of production are the Rustenburg and Nelspruit districts of the Transvaal, Natal, and Zululand, a large proportion of which is situated on the Pongola Poort and Candover Estates. The results which have been obtained give some promise that the cotton industry is likely to become a permanent one. Besides those districts in the Transvaal and Natal, including Swaziland and Zululand, which are already growing cotton, there are in addition large tracts of land which have a soil suitable for cotton culture. These latter districts are, however, at present uncultivated and their development must largely depend on the question of the labour supply. Although labour is scarce in many districts, and the mines absorb a large proportion of the available supply, there is stated to be in South Africa as a whole a certain quantity of labour which is lying idle or dormant, but which might be put to agricultural work. In order to guard against the introduction of insect pests, stringent regulations have been enacted against the importation of cotton seed and unginned cotton into the Union from any other country except under Government supervision. For the successful development of cotton-growing in South Africa and in all cotton-growing countries, it is of the utmost importance to maintain a pure seed supply. One of the most suitable varieties which has been produced in the Union is the "Bancroft" type, and if this seed can be obtained and kept pure, then it might be continued. That most excellent cotton can be grown has been proved, that there are facilities both in suitable soil and labour for growing a large crop is also beyond doubt, and as the Department of Agriculture is now tackling the problem seriously progress should be well maintained

The newly-established Colony of Southern Rhodesia is a promising area as a supplementary source of supply. It has been known for many years that cotton could be grown, and no doubt the present high prices will help to induce the farmers to consider the question of cotton cultivation on an extensive scale. In North-eastern Rhodesia cotton has also been grown for some years, but the crops for the past three or four years have not been very large. This is partly due to tobacco proving more remunerative and cheap transport facilities being non-existent. Geographically, North-eastern Rhodesia is a part of Nyasaland. Transport is the problem, and it is doubtful if there can be any large development until that territory is connected by railway with either the Zambesi or Blantyre.

Australia. It is now clear that certain parts of the Commonwealth of Australia are capable of producing cotton of high standard and staple, and great efforts are being made to establish the cotton-growing industry. The Association has taken an interest in cotton-growing in Queensland for a number of years, and the following offer was made by the Association in August 1920.

> The British Cotton Growing Association will guarantee for a period of five years a selling price of 1*s*. 6*d*. per lb. of lint for all clean cotton of good quality forwarded to them, freight and insurance paid, for sale in Liverpool. The cotton to be produced from cotton seed such as Allen's Improved, Cook's Long Staple, Egyptian Sakel or similar long-stapled varieties, such seed to be issued by the Queensland Agricultural Department. The guarantee to date from 1st January, 1920, and the Association's total loss throughout the period to be limited to an amount not exceeding £10,000.

The amount of £10,000 eventually was exhausted, and the Queensland Government decided to continue to guarantee the growers a fixed price. Queensland at present is the only Australian State where cotton is grown in appreciable quantities, although the northern parts of New South Wales have made considerable experiments. The area under cultivation for cotton in Queensland

has increased from 166 acres in 1920 to over 100,000 acres in 1924, and in addition it is estimated that between 20,000 and 30,000 acres will be planted in New South Wales this year. The North-west of Western Australia and the Northern territories also have possibilities. The development of cotton-growing in Australia has two interesting features. One is that only white labour is employed, and the other is that the industry is being developed along lines tending to confine cotton production to small areas and incidental to other farming operations. The Commonwealth and State Governments are doing all they can to encourage the cotton-growing industry, and have adopted a bold policy of guaranteeing a price up to $5\frac{1}{2}d.$ per lb. for all first quality seed cotton delivered at the ginneries. The quality of the cotton is excellent. The Queensland Government have further legislated to prohibit the cultivation of ratoon cotton. The Boll-weevil is not yet known, but there are other pests such as the Boll-worm, etc.; therefore by prohibiting ratooning and insisting on the old plants being uprooted and burnt every year, it is hoped to keep the country clear as far as possible of the chief pests which prey upon cotton.

The West Indies. The bulk of the cotton grown in the West Indian Islands, principally in St. Vincent, Montserrat, Barbados, St. Kitts, etc., is what is known as Sea Island, a distinct variety; the superfine type from St. Vincent is the longest and finest cotton grown in the world. With the rapid change that was experienced in the cotton trade from a state of great prosperity to deep depression, the demand for Sea Island cotton declined. The Fine Cotton Spinners' and Doublers' Association, however, boldly came to the rescue and have continued to purchase practically the whole production for several years past. The goods made from Sea Island cotton are largely used for luxury purposes, and will probably be the last to feel any advance in view of the general poverty of the nations. The Pink Boll-worm has also, unfortunately, made its appearance in the Islands of Montserrat and St. Kitts, and although every precaution was promptly taken by the Imperial Department of Agriculture to stamp out the pest, and especially to prevent its spread to other Islands, it is feared the outbreak

will result for a time in some curtailment of the area under cotton. The quantity produced is between 4,000 and 5,000 bales, and is quite sufficient to meet the present demand. Most of the plantations are in the hands of Europeans, although the peasant growers produce quite a fair quantity. An Imperial Agricultural College has recently been established in the West Indies and is situated in the Island of Trinidad. The foundation stone of the new building was laid on 4th January last. It is anticipated that the work to be carried out by this college should be of considerable value in connection with cotton cultivation in all tropical countries.

Iraq (Mandated). Experiments which were made shortly after the Armistice by the Agricultural Department proved that this country offered immense possibilities, the yield per acre in some instances being higher than is obtained in other parts of the world. Owing to the small rainfall, however, cotton will have to be grown under irrigation. The soil and climate largely resemble that of Egypt. The experiments mentioned above indicated that a variety which has been given the name of "Mesowhite" was about the most successful. The great need of Mesopotamia, however, is population. The country is larger than the United Kingdom and yet its people do not number as many as those in the West Riding of Yorkshire. In the winter of 1919-20, the Association sent out a delegation to that country to investigate the possibilities on the spot, the result of which was a decision to commence direct operations and a ginning plant was sent out and is now working at Baghdad. This plant deals with all the cotton at present grown. The production for 1922-23 season was 350 bales, and for the present season about 1,500 bales. Under the more healthy and secure conditions now being obtained, the population will no doubt increase, and with the provision of the necessary capital for development work there is every possibility of obtaining 100,000 bales, which it should be possible to produce on land provided with water from the existing works. But the ultimate possibilities of the country with a sound irrigation system and a largely increased population are estimated at one million bales annually.

Ceylon. Experiments by cotton and rubber planters were conducted over several years, and the Association some years ago erected a small ginning plant, but cotton as a commercial crop was not a success, mainly owing to the excessive rainfall and to the fact that there were other crops which paid the planters better, principally tea, rubber, etc., and consequently the industry was not persevered with. We have not the slightest doubt that cotton can be grown in Ceylon, and at prices ruling to-day it should be a payable proposition, more especially as there is not the same keen competition from other products.

There are also many other places where experiments have been carried out and where a certain quantity of cotton is grown, especially in Cyprus, Malta, Fiji, Palestine, British Guiana, etc. In other spheres the possibilities have not been such as to warrant further expenditure and trouble. The result of the work to-day is that about one-quarter of a million bales of cotton are produced in the new fields of the British Empire, and many of the types are not only equal to but an improvement on similar types produced in America and Egypt. In some colonies cotton-growing has not been attended with the full measure of success which was looked for, but in many places its progress and expansion has quite come up to expectations, and what is of more importance is the fact that the permanency of the industry in those new areas has been established, but we want to see the project carried to maturity, and that is to have the Empire making good any deficiencies in our raw cotton supply, but new and experimental work is of necessity a slow growth.

The magnitude of the task which the Association has set out to accomplish proved too great, for after all they had certain limitations, and as the result of recommendations the Empire Cotton Growing Corporation was formulated, and was established under Royal Charter, dated 1st November, 1921. Under its Charter the Corporation will, amongst other functions, have power to—

(1) Assist in the enlargement and strengthening of the Agricultural Departments of the Dependencies and

Colonies, and to provide facilities for training men for posts under these Departments.

(2) Establish a bureau for the dissemination of information on cotton-growing and to issue a journal containing useful information on the subject.

(3) Undertake the marketing of crops where this will prove of assistance to the local Government. This latter work will doubtless be done in conjunction with the British Cotton Growing Association.

During the war the British and Egyptian Governments controlled the buying and selling of Egyptian cotton, the profits amounting to a large sum. Half of this money was retained by the Egyptian Government, and of the balance which came to the British Government it was decided that one million sterling should be handed over to the Empire Cotton Growing Corporation. Moreover, spinners and manufacturers also approved of the proposal of a levy, which has been made obligatory on all users and is enforceable by law, in terms of an Act of Parliament, which received the Royal Assent in July 1923. The Corporation has already got to work, having experts in South Africa, Australia, Tanganyika and Nyasaland, who are engaged in the production of suitable seed, elimination of insect pests, etc. The British Cotton Growing Association retains its separate identity and will work in close co-operation with the Corporation, only its chief work in the development of new areas will be, where necessary, the handling of the cotton when grown, which comprises the ginning, baling and marketing of it, and attending to its disposal in the home markets. The Association will also attend to the supplying of stores, buildings, machinery, etc., and in many other directions continue to assist the industry for which it has laboured since 1902.

In conclusion, it may be stated that the results have been attained by progressive stages, but they have necessitated a vast amount of closely concentrated work and the task has been no light one. Like every other great undertaking, the movement has needed the helping hand and sympathetic assistance of H. M. Government, especially of the Colonial Office. The Imperial

Institute did most important work in the scientific examination of cotton samples and the provision of men for the Agricultural Department. Last, but not least, a warm tribute must be paid to the Governors and officials of the new cotton-producing countries, who without exception have taken the keenest interest in the work; but it is upon the Department of Agriculture that the real burden of the day has fallen and to whom the success already achieved is largely due, and I take this opportunity of tendering to all the grateful thanks of Lancashire for the part they are playing in increasing the world's cotton supply.

THE MAINTENANCE RATIONS OF ANIMALS.*

BY

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A MAINTENANCE ration may be described as that which will keep an animal that is in a resting non-producing condition and in good health in the same condition and at the same weight *for an indefinite period.* A diet which keeps an animal at a constant weight and *apparently* in good health for a short period is not necessarily a true maintenance ration. For example, certain monkeys kept in confinement in a zoo which are accustomed under natural conditions to a varied diet, including insects and grubs, may live for a considerable time in confinement on a diet of mixed fruits and nuts. When eventually these animals die, post-mortem examination not infrequently reveals a hitherto unsuspected osteomalacia, evidence that the diet has been deficient. It is, therefore, to be assumed that long before symptoms of illness became evident the animals had been living in a condition of "half-health," hence one would not be justified in regarding this diet as a maintenance ration, notwithstanding the fact that it does maintain life even to the extent of several years.

In connection with the domesticated animals, in many cases it is very difficult to say what really constitutes a true basal ration if it is agreed that the diet must maintain health for a long and not a short period. There are many factors which have to be taken into consideration, any one of which, if neglected, may tend to lower the health-level of the animal. Every basal ration should be constructed so as to allow for sufficient exercise, as a certain minimum of exercise is essential if health is to be maintained. The writer;

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* Reprinted from *The Lancet*, dated 19th July, 1924.

when feeding oats stained with methylene-blue to horses for the purpose of determining the rate of passage of food through the intestine, found that a few minutes' walking exercise round a yard caused the fæces to be evacuated several hours earlier than when the same animals were kept standing tied up in a stall. Dogs accustomed to regular exercise, and thus regular evacuation of the rectum and bladder, when kept confined in a cage fail to get rid of their waste products as soon as they should, and thus real health is not maintained. It is well known that cattle and horses when conveyed by ship, even for a short distance, shew a gain in weight out of proportion of the amount of food they could have digested. This temporary increase in weight is due to the accumulation of indigestible food and waste products in the intestinal tract. This is a very important point to keep in mind when carrying out feeding experiments with animals confined in cages, for this delay in evacuation of residual matter, if continued for an appreciable period, is bound to have a detrimental effect on the health of the animals.

Requirements for a basal ration.

The requirements for a proper basal ration for animals may be summarized as follows: (1) The net caloric intake must be equivalent to the basal fasting katabolism, together with an allowance for the increased metabolism due to the specific dynamic action of the food consumed. (2) It must supply sufficient net energy for adequate exercise. (3) Additional metabolisable energy may be required simply for the purpose of supplying heat in the case of animals where the critical temperature is of practical importance. (4) There must be sufficient protein to equalize nitrogen outgo. (5) There must be sufficient "coarse" food in the ration to open out the concentrated food and thus allow the free access of digestive juices. (6) An adequate bulk to the ration is necessary to cause the optimum distension of the stomach and intestines necessary for proper digestion and to give that sense of repletion without which the animal will not be contented. (7) The protein and non-protein constituents must be in proper proportion the one to the other, as also must the fat to the protein, for the optimum digestion of the

food to take place. (8) There must be a properly-balanced and sufficient mineral supply to ensure a normal ionic concentration. (9) The food must be suitable for the particular species of animal. (10) An adequate supply of vitamins is essential. (11) Finally, the food must be palatable.

Neglect to study the above points when formulating rations, especially when the object of feeding an animal is to conduct a feeding experiment, may be the cause of very misleading results, and it should be remembered that whilst animals possess a considerable flexibility in their capacity to utilize strange and unnatural food, this power to acquire tolerance is not unlimited.

Maintenance requirements of horses and cattle.

Maintenance requirements of farm animals are sometimes expressed in terms of *net energy*, which is equivalent to Kellner's production starch equivalent, or, on the other hand, in terms of *gross digestible energy*, which is equivalent to Armsby's *metabolisable energy*, or the so-called maintenance starch equivalent. The caloric value of 1 lb. of metabolisable energy expressed as starch is 1,710 kilo-calories (C); that of 1 lb. of net energy expressed as production starch equivalent is 1,071 C.

In accordance with our conception of a true basal maintenance ration, the requirements for the maintenance of a horse have been studied by many interested in animal nutrition. A critical study of the investigations that have been made to this end has been provided by Armsby in his "Nutrition of Farm Animals."[1] Armsby accepts the finding of Zunts and Hagemann, which is that for an animal weighing 1,000 lb. there is required a total of 11,900 C. of metabolisable energy made up as follows:—

Net energy for internal work	4,100 C.
Additional required for heat production	7,800 C.
Total metabolisable energy	11,900 C.

This caloric requirement is not taken to mean the physiological minimum but an economic minimum.

[1] Armsby, H. P. *The Nutrition of Farm Animals*, New York, 1917.

In 1917[1] I estimated the maintenance requirement for horses and, basing my calculations on a study of former investigations and on the rations given in practice, suggested that a total of 13,000 C. of metabolisable energy would meet the demands of a 1,000 lb. horse—that is, a light draught horse—where the temperature of the surrounding air was not too low, and provided that the ration contained sufficient net energy for physiological purposes. It was also assumed that this 13,000 C. would allow for the minimum of exercise required to maintain health.

It would appear, however, to be very difficult, if, indeed, it is not even impossible, to fix with any high degree of accuracy the maintenance requirements of horses and to express them in terms of calories. This is so for two reasons: first, because there is such divergence between the findings of the various investigators as to what constitutes a maintenance ration; and, secondly, because we have but rudimentary knowledge of the real caloric value of the different foods for these animals, either when fed as single foods or in combination, as when a composite diet is given, as, for example, hay, straw and grain. It is well known that the digestibility, and hence the net energy value, of foods varies according to the combination in which they are given.

When calculating the rations of horses, it has been commonly assumed that the same food has an equal value for both the ruminant and the horse, and though Kellner himself says that his "starch values" may be applied to both horses and ruminants this is doubtful at least with a number of foods. Indeed, Armsby gives a much higher value to some foods for the horse than he does for ruminants, so that as some people use Kellner's figures and some Armsby's, it is not surprising that conflicting results are obtained.

If we assume Kellner's deductions to be correct and that 6·6 lb. of "starch" will satisfy the demands of a resting horse weighing 1,000 lb., then 16 lb. of "good" quality meadow hay wil

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[1] Linton, R. G. The Maintenance Requirements of Horses. *Vet. Jour.*, April 1917.

constitute a maintenance ration so far as its energy value is concerned, since this quantity of hay has a metabolisable energy of 12,483 C. and a net energy value of 5,355 C. We know in practice that 16 lb. of hay is fully as much as an animal of this size could eat in a day. If we refer to any published tables of food values, we find that, while it is stated that 16 lb. of "good" meadow hay has a net energy value of 5,355 C., an equal quantity of "very good" meadow hay had a net value of 6,954 C. So that here we have a difference of 1,600 C. in a diet of 16 lb. of hay, according to whether the feeder classes it as good or very good. To illustrate still further what confusion exists regarding food values for animals and their application when an attempt is made to construct a diet on "scientific" lines, we may refer to an example of a maintenance ration for a bullock given by Prof. T. B. Wood in his recently-published "Animal Nutrition."[1] On page 169, Wood quotes Kellner's figure for the net energy value of barley straw at 209 C. per lb. and Armsby's figure at 366 C. per lb. Accepting the latter figure which, as he says, was determined much more recently, Wood considers that 17 lb. of barley straw will supply sufficient net energy for the maintenance requirements of a 9 cwt. bullock, that is, 6,000 C. of net energy. (This ration is, of course, deficient in protein, as Wood points out.) In subsequent pages, when compounding rations containing barley straw for bullocks, Wood makes use of Armsby's figure, but in his table of food values leaves the agriculturist to construct his rations from Kellner's figure, which is the one, rightly or wrongly, that is in general use. What this difference in values means is made clear when it is understood that if Armsby's figure is used, then 16·5 lb. of barley straw will presumably supply the 6,000 calories required, and if Kellner's be utilized, then no less than 28·7 will be necessary. If Armsby's figure is right, then Kellner's must of necessity be wrong, and as dairymen have been in the habit of constructing "scientific" rations for their cows from Kellner's figures, they will be perturbed at finding their careful calculations liable to so great an error.

[1] Wood, T. B. *Animal Nutrition.* Cambridge, 1924.

Fallacies to be avoided.

Attention is drawn to the above simply for the purpose of emphasizing the danger of utilizing values that are assumed to be correct. When we consider still further the great variation that exists in the quality of the foods given to animals, the divergence in views among those who have studied animal nutrition as to the energy required for maintenance, the fact that in many instances food values, such as they are, for ruminants are assumed to be applicable to the horse and, indeed, even to the pig, and many other conflicting assumptions, one is naturally led to ask, how is one to determine what are maintenance rations for the various domesticated animals ? It would appear to be necessary before conducting a feeding experiment for the purpose of determining a fine point in animal nutrition to find out the maintenance requirements for each animal for the particular food used. This can only be done by careful and prolonged experiment.

Having determined the maintenance requirements of an animal of any given weight, those for other animals of the same species, but of different weights may be calculated approximately by means of the well known surface law of Rubner. Though not sufficiently accurate for experimental work, this method may be applied to everyday use provided that it is not interpreted too literally. A considerable margin for error must be allowed. Estimates of the weight of horses are often exaggerated. The writer found the weight of British Army horses in good hard-working condition, not fat, to be as follows : Heavy draught mules 1,350 lb., heavy draught horses 1,300 lb., light draught horses 1,150 lb., light draught mules 1,100 lb., riders first class 1,075 lb., and riders second class 975 lb. The average weight of heavy draught horses kept in a fatter condition than those in the army is 14 cwt. It is an exceptional animal that weighs over 16 cwt., though some approach a ton in weight.

A maintenance ration for horses that in the past few years has been well tested is that laid down by the Ministry of Agriculture for horses exported from this country to Europe. For horses of the larger type this is 15-20 lb. per day, for smaller animals 10-15 lb.,

and for small ponies and asses 5–10 lb. The average weight of these animals, excluding small ponies, is 11 cwt. Some few months ago the writer had a consignment of 22 horses weighed immediately before embarkation and again immediately after disembarkation at Antwerp. Every horse showed a marked increase in weight, and while, as stated before, this increase is in part undoubtedly due to incomplete evacuation of the intestinal tract, it at least indicates that the quantity of hay consumed was not below maintenance requirements.

* * * *

Notes

OBSERVATIONS ON THE FEEDING OF HORSES ON *LATHYRUS SATIVUS*.

THE question of the poisonous properties often ascribed to *Lathyrus sativus* (a small and somewhat three-cornered mottled pea) by older writers has recently been under investigation, not with a view to utilizing the grain as animal food, but to arrive at some practical decision as to whether or not a small percentage as an adulterant to gram might with safety be allowed in animal rations.

To arrive at some idea of the percentage of *Lathyrus sativus* contained normally in gram as purchased and supplied to the Army, samples were obtained from stations covering practically the whole of India, these were carefully hand-picked and the following adulterations recorded :—

Station	Percentage *Lathyrus sativus*	Station	Percentage *Lathyrus sativus*
Risalpur	0·05	Secunderabad	..
Rawalpindi	..	Mhow	0·11
Jubbulpore	0·05	Ambala	..
Jhansi	0·04	Kirkee	0·06
Nowshera	0·11	Allahabad	3·87
Bangalore	0·22	Lucknow	3·37
Delhi	..	Muzaffarpore	0·05
Meerut	0·41	Quetta	..
Lahore	0·80	Karachi	..

Records available contain no mention of ill effects of feeding gram thus adulterated to animals.

Following on this, feeding experiments were carried out at the Station Veterinary Hospital, Lucknow, and as it has been

suggested that the poisonous properties attributed to *Lathyrus sativus* may be due to contamination by other small seeds not identified, the *Lathyrus sativus* was cleansed of all other grains before feeding—from 16 maunds (1,280 lb.) of *Lathyrus sativus*, 30 lb. of other grains were extracted.

Seven horses were selected for the experiment which was continued over a period of 35 days.

Two horses received 10 lb. *Lathyrus sativus* per diem with chaff and hay.

Two horses received 5 lb. *Lathyrus* per diem with 5 lb. bran, also chaff and hay.

Two horses received 2 lb. *Lathyrus*, 4 lb. bran, 4 lb. barley, chaff and hay.

One horse received gradually increasing quantities of the seeds removed from the *mutter* pea by screening, starting with 2 oz. four times a day up to 8 oz. four times a day, in addition to the ordinary hospital diet.

It was found that the animals had considerable difficulty in masticating the grain (*Lathyrus sativus*), therefore from the 3rd day onwards it was given crushed.

All the animals were either ridden or lunged twice a day.

Temperature, pulse, and respiration of all animals remained normal throughout the time they were under observation.

The only abnormality noticed was that one horse showed inco-ordination of movement on the 17th day which was more marked on the following day; afterwards the animal improved and became normal although no alteration was made in diet and the incident was probably not attributable to *Lathyrus sativus*.

As a final experiment all animals in hospital received 1 lb. of *Lathyrus sativus* per diem for 4 days. Nothing abnormal was noted.

These observations are of interest. The evidence of older observers that lathyrism (paralysis) in animals does at times result from feeding *Lathyrus sativus* cannot be dismissed.

It may be that the grain is only poisonous:—

(*i*) Under certain conditions of growth.

(*ii*) Intermittently as in the case of linseed and mustard as recorded by Major-General Sir John Moore, K.C.M.G., K.C.B., F.R.C.V.S., Mr. H. Tudor Hughes, B.Sc., F.R.C.V.S., and Mr. G. T. Dunne, F.R.C.V.S., in the "Veterinary Journal" of January 1924, the poison in such cases being due to a glucoside formed under certain conditions, e.g., fermentation.

This view appears to be the most likely one and is supported by the fact that the poisonous effects in all these cases are reported to be destroyed if the grain is boiled, but this, however, was not confirmed in further experiments on three horses receiving daily 2 lb. of *Lathyrus sativus* for a period of 2 months after it had been soaked for 12 hours and fermented.

The results of the experiments lead one to conclude that the adulteration of gram as normally supplied to the Army in India can be ignored as far as it is likely to produce any ill effects on animals. [W. H. WALKER, LT.-COL., R.A.V.C.]

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UNITED PROVINCES POULTRY ASSOCIATION.

ALTHOUGH the model farm of the United Provinces Poultry Association at Lucknow was to a large extent wrecked by the devastating floods of September 1923, which involved the removal of the entire stock of 450 birds to very cramped quarters for over a month just at the time when the breeding pens had been mated for the season, the financial aspect of its working, as disclosed in the fourth annual report for 1923-24, was quite satisfactory. The gross receipts of Rs. 9,513 not only covered the actual working of the farm but also provided the salary of Rs. 300 per month paid to the farm manager which, if the farm were a private concern, would be profit to the owner-manager. When it is remembered that the farm carries only a hundred head of breeding stock, there will remain no doubt that there is scope for reliable commercial poultry farms in the country.

The educational side of the Association's work has largely developed and is by no means confined to the United Provinces

only. The winter classes for students are well attended, and during the year under report over a dozen lads were fully trained in poultry farming. The success of the annual egg-laying competition and all-India show has created so much interest in the countryside that poultry shows have become prominent features of various agricultural fairs held in the province, and at the Etah Exhibition as many as 2,000 birds were offered last year for competition. It is also gratifying to know that many Indian zemindars are opening poultry farms on their own account with the foundation stock supplied by the Lucknow farm, and there is a growing demand for trained managers. Although considerable stimulus has been given to this valuable cottage industry by the activities of the Association during the last four years, much remains to be done, and it is to be hoped that the Association with its energetic Secretary will get a fresh lease of life when the experimental period terminates this year.

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AMERICAN COTTON SITUATION.

"THE MANCHESTER GUARDIAN COMMERCIAL" of 21st August, 1924, has issued its second annual review of American cotton. The progress and prospects of the new cotton crop are very fully considered, special attention being paid to the part played by the weather and the Boll-weevil. Methods of fighting pests, as well as methods of cultivation, fertilization and marketing are dealt with in so much detail that the supplement provides a valuable guide to cotton-growers in the United States as well as in the new fields.

Mr. W. G. Reed in reviewing the past season writes:—The season is closing with sufficient cotton on hand to meet present requirements, and with the whole cotton trade anxiously following new crop prospects. There are grave fears that the early movement will not be sufficient to provide cotton for the increased demand expected from spinning mills. The carry-over to the new season is more than half a million bales smaller than that of a year ago, which at that time was thought to be lower than was consistent with safety. The trade, however, has managed to get through

another year of approaching famine, but only because of sharp reductions in consumption; with the impoving trade which many competent observers expect in the early fall supplies of cotton will be little more than adequate; the size of the new crop, which was considered of prime importance a year ago, is of even greater moment this year, and until an adequate crop is assured nervous markets must be expected, and a cloud no bigger than a man's hand in the southern skies will crowd telegraphs and cables with messages of hope or fear to the spinners of the world.

Mr. C. T. Revere, of the New York Cotton Exchange, comments on the new crop as follows:--The two Carolinas each promise a shorter crop than last season. North Carolina has suffered from a late start that was complicated by too much rain in June and early July. The situation there has improved considerably of late, but the production probably will fall considerably below last season, with fair indications for a minimum of 800,000 bales. South Carolina is in somewhat the same position as its northern neighbour. The Piedmont districts have done fairly well, but there has been too much rain elsewhere until recently. The State might run close to 800,000 bales, but a fairly safe minimum, barring unusual weevil damage not now indicated, would be 700,000 bales.

Georgia, in my opinion, will furnish one of the surprises of the crop season. Though some estimates are for a yield of 1,000,000 bales, it would not be surprising if the State came closer to 1,500,000 bales, remarkable as such a recovery may appear. The absence of heavy weevil damage furnishes the explanation. Alabama stands a chance of raising about as large a crop as two years ago, as weevil damage so far has been comparatively slight. Mississippi, it would seem from current reports, should go well above 1,000,000 bales, and might easily reach 1,200,000. Tennessee is problematical, although 300,000 bales is apparently a reasonable minimum. Louisiana has suffered from heavy drought, but has escaped the weevil damage that has caused such havoc for a number of years. No guess could be made as to its prospects. Arkansas may fall as low as 800,000, but there are some very good judges of crop conditions in that State who estimate the yield at 1,000,000 to

1,200,000. Oklahoma has scored a remarkable recovery, with excellent prospects for a yield above 1,000,000 bales. The far western States of Arizona, New Mexico, and California all have prospects for the largest crops in their history.

As to Texas, August will have to tell the story. Anything can happen there, but some portions of the State already have a fairly large crop made in well-developed bolls. This is particularly true of the Red River section of North Texas and in portions of West Texas. South-west Texas has had rather too much rain. West Texas has had no such drought as prevailed over that district last season, though the benefits accruing from scattered showers, ranging from one-third of an inch to two inches, represent a question open to controversy.

Mr. G. W. Fooshe, writing on the influence of weather on the yield, reports that Boll-weevil emergence this season has proved strikingly light as compared with other more recent years. It may also be noted, in this connection, that infestation up to the middle of July was exceedingly light in practically the whole of the cotton-producing area. Too much rain has fallen in the Carolinas and Georgia, and there is fear that, if these are unduly prolonged, the foundation may be laid for rapid spread of these pests. But, taking the remainder of the belt, rainfall during the thirty or forty days prior to mid-July proved exceedingly light. Furthermore, with the exception of a few days of cool weather round the fourth of the current month, temperatures have been abnormally high. Even in June temperatures ranging from 100 to 112 degrees maximum prevailed over the greater portion of Texas and Oklahoma, while maxima of 90 to 95 appeared in the central valley States and the south-east. The heavy rains in the South Atlantic States are keeping temperatures comparatively low there, but they are above the seasonal average in all the remainder of the cotton-producing area.

Prevalence of these high temperatures is tending to keep infestation down to pretty small proportions. At the same time, absence of anything beyond widely scattered showers is making it possible for planting interests, equipped to do so, to use calcium arsenate and other poisons with a very high degree of effectiveness.

Thus with the possible exception of North Carolina, South Carolina, and Georgia, where some increase in infestation is reported, there is ground for the hope that weevil may prove far less numerous and far less destructive than in any recent year. Already reports are coming in from Louisiana, Arkansas, and Mississippi to the effect that, in the absence of weevil of importance, more fruitage has already been taken on by the plants than came to maturity during the preceding season.

The supply of poison for combating the Boll-weevil is dealt with by Miss E. M. Miller of the National Bank of Commerce in New York. During 1923, she writes, about 31,000,000 pounds of calcium arsenate were consumed in the United States. Part of this was used in order to combat the army worm, instead of the weevil. The Standing Committee on Arsenic estimated that 1,674,000 acres of cotton, or 4·4 per cent. of the total American acreage, was treated. Early in 1924 it was stated by the Committee that if the price of calcium arsenate should remain low through the current season—that is, below 13·5 cents per pound, f. o. b. factory—its use this season might double, possible consumption being estimated at from 65,000,000 to 75,000,000 pounds. This amount would treat nearly 4,000,000 acres, or 10 per cent. of the total acreage planted to cotton. Calcium arsenate was quoted on July 25th at 9 cents per pound, New York. Some sections now report that 10 per cent. of the total acreage may be dusted with calcium arsenate, but it is probable that the percentage for the cotton belt as a whole will be materially lower. The ineffectiveness of calcium arsenate in wet weather and the large measure of control exerted by heat and sunshine, whether or not calcium arsenate is applied, tend to retard the rapid extension of its use.

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PEACE AND PROGRESS OF AGRICULTURAL POPULATION.

THE following has been received from the President of the International Institute of Agriculture, Rome:—

The seventh meeting of the General Assembly of the International Institute of Agriculture took place on May 25th last, when

on the motion of the French Government the following resolution was passed unanimously :—

"The General Assembly

being of opinion that farmers in all countries represent one of the elements that make for peace as between peoples; that order, tranquillty and continuity in daily work are the essential factors in agricultural prosperity and progress and thus the source of the well-being of Nations;

that the maintenance of the idea of peace is indispensable to the order and tranquillty of the peoples;

that farmers are among those who are most chiefly interested in the suppression of the dangers as well as of the horrors and disasters of war;

considering that the International Institute of Agriculture was founded, according to the generous sentiment of His Majesty Victor-Emmanuel III, King of Italy, in order that it might become a means of promoting solidarity among all farmers and thereby a powerful instrument of peace, resolves—

(1) to request the adhering States to establish among Agricultural Associations and Societies an active propaganda for the encouragement among farmers of the idea of agricultural progress which is indissolubly connected with peaceful development in international relations;

(2) to instruct the Permanent Committee to enter into communication with the various Governments in order, in agreement with them, to discover the best practical methods for influencing public opinion throughout the world, basing this propaganda on the necessity for the order, tranquillity and peace of the agricultural population in each country."

The General Assembly wishes emphatically to testify to the keen desire of the representatives of world agriculture, of whom the Institute is in the international sphere the chief representative organ, to see the agricultural classes in all countries take an active part in a pacific movement calculated to enhance the well-being and happiness of mankind, and to the pleasure with which they would welcome such action.

The General Assembly of the Institute considered that it could best express its sentiments by adopting as its own the generous resolution proposed by the French Delegation.

In communicating this resolution by the present letter I would ask you to be so good as to take steps to bring its purport to the notice of the agricultural classes in your country pending such action as the Permanent Committee may adopt with a view to giving it successful effect.

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

DR. F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S., has been appointed to officiate as Imperial Economic Botanist from 25th August, 1924.

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MR. P. V. ISAAC, B.A., D.I.C., M.Sc., F.E.S., Second Entomologist (Dipterist), Pusa, has been granted leave on average pay for one month and 24 days from 30th October, 1924.

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MR. T. F. MAIN, B.Sc., Offg. Director of Agriculture, Bombay, has been granted leave on average pay for six months and 24 days from date of relief by Dr. H. H. Mann.

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SARDAR G. S. CHEEMA, M.Sc., Horticulturist to Government, Bombay, has been granted leave on average pay for seven months and 20 days from 1st April, 1925. Mr. H. P. Paranjpye officiating.

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MR. RUDOLPH D. ANSTEAD, M.A., Director of Agriculture, Madras, has been granted leave on average pay for eight months from 20th March, 1925.

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MR. G. R. HILSON, B.Sc., Cotton Specialist, Madras, has been granted combined leave for eight months from the date of his relief as Offg. Secretary, Indian Central Cotton Committee.

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MR. P. H. RAMA REDDI, M.A., B.Sc., Deputy Director of Agriculture, III Circle, Madras, has been granted leave on average pay for six weeks. Mr. T. B. Nayudu officiating.

DR. H. M. LEAKE, Sc.D., M.A., Director of Agriculture, United Provinces, has been granted combined leave for one year, three months and 30 days from 22nd August, 1924, in continuation of the leave already granted to him.

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RAI SAHIB PANDIT NAND KISHORE SHARMA, Divisional Superintendent of Agriculture, Bundelkhand Circle, has been appointed to officiate as Deputy Director of Agriculture, Central Circle, Cawnpore, *vice* Mr. T. R. Low granted leave for one month.

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MR. R. L. SETHI, M.Sc., Economic Botanist to Government, United Provinces, was on leave on average pay for one month from 11th September, 1924, Mr. T. S. Sabnis, M.Sc., officiating.

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MR. H. W. STEWART, Agricultural Engineer, Bihar and Orissa, was on leave on average pay for 12 days from 14th to 25th October, 1924.

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SARDAR DARSHAN SINGH, M.R.A.C., Deputy Director of Agriculture, II Circle, Punjab, was on leave on average pay for three months and 16 days from 15th June, 1924, Choudhury Mohammad Abdulla officiating.

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A SPORTING COLLEGE.

The College of Agriculture, Poona, is marked for its sporting spirit. A most striking proof of this was given by its successes in the recent Poona inter-collegiate sports. These sports are held annually in September and this (1924) is their fourth year. There are three Arts and Science Colleges, one Engineering College and one Law College in Poona, in addition to the College of Agriculture. Of these six, the College of Agriculture is the smallest, numbering 173 students against over 1,000 of the biggest, the Fergusson College. In spite of this, the College of Agriculture this year

carried off the Individual Championship and came second among the colleges for the College Championship. This almost equalled the college record in 1920, when the College of Agriculture carried off both Individual and College Championships. In the current year the College of Agriculture annexed in all twelve trophies, including both the first and second prizes in boxing, which was introduced for the first time. His Excellency the Right Hon'ble Sir Leslie Orme Wilson, P.C., G.C.I.E., C.M.G., D.S.O., in the course of his speech at the end of the gathering, said that, while the College of Agriculture might be small in numbers, it amply made up for that by the enthusiasm with which it supported its athletic representatives.

Review

Birds of an Indian Garden.—By T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.; and C. M. Inglis, M.B.O.U., F.E.S., F.Z.S. In five parts with thirty coloured plates and numerous illustrations in the text. (Calcutta and Simla: Thacker, Spink & Co.) Price, Rs. 2 per part.

The series of papers dealing with some of the more common of our Indian birds, which has been appearing in this Journal for the last five years and which will close with this issue, has attracted considerable notice, and to meet the insistent demand for their republication in book form, Messrs. Thacker, Spink & Co. have been autherized to bring out this volume under a new title to avoid confusion with works of similar titles by other authors. In the original issue we were compelled to publish the articles without any regard to systematic order as the plates were completed. In re-issuing the series, however, the opportunity has been taken to re-arrange the papers, to amend the nomenclature in accordance with Mr. Stuart-Baker's Hand-list of Indian Birds, and also to add some black-and-white illustrations. This is the first book on Indian birds in which the commoner species have been so beautifully illustrated, and without doubt much of the popularity which these papers have attained during their appearance in this Journal has been due to the excellent series of plates printed from Mr. Inglis's original paintings. It is hoped that this publication will not only be helpful in enabling the non-ornithological reader to become acquainted with and take deep interest in bird-life, but will also provide the teachers in our secondary schools with a text for a branch of Nature study which is bound to appeal to their pupils.

The first part which has already been published contains plates and descriptions of the Jungle Crow, the House-Crow, the Jungle-Babbler, the Red-vented Bulbul and the Black Drongo or King Crow. It is proposed to bring out subsequent parts at short intervals.

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

1. Crops and Fruits, by J. R. Ainsworth-Davis. (The Resources of the Empire Series, Vol. I, Pt. 1.) Pp. 144. (London : Ernest Benn, Ltd.) Price, 21*s*. net.

2. Meat, Fish and Dairy Produce, by J. R. Ainsworth-Davis. (The Resources of the Empire Series, Vol. II.) Pp. 104. (London : Ernest Benn, Ltd.) Price, 21*s*. net.

3. Cotton in Australia : The possibilities and the limitations of Australia as a cotton-growing country : containing numerous illustrations and graphs, together with data relating to the Australian Climate, Rainfall, Temperature, Soil Analyses and Cost of Production, by Richard Harding. Pp. xviii+270. (London : Longmans, Green & Co.) Price, 12*s*. 6*d*. net.

4. Rubber, Tea and Cacao, with special sections on Coffee, Spices and Tobacco, by W. A. Maclaren. (The Resources of the Empire Series, Vol. V.) Pp. 334. (London : Ernest Benn, Ltd.) Price, 21*s*. net.

5. Outlines of Fungi and Plant Diseases ; for students and practitioners of Agriculture and Horticulture, by F. T. Bennett. Pp. 266. (London : Macmillan & Co.) Price, 7*s*. 6*d*.

6. Plant Alkaloids, by T. A. Henry. Second edition. Pp. viii+456+8 plates. (London : J. & A. Churchill.) Price, 28*s*. net.

7. The Determination of Hydrogen Ions, by W. Mansfield Clark. Second edition. Pp. 480+42 figs. (Baltimore : Williams and Wilkins Co.) Price, $5·50.

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. The Mahali Disease of Coconuts in Malabar, by S. Sundararaman, M.A.; and T. S. Ramakrishnan, B.A. (Botanical Series, Vol. XIII, No. 4.) Price, As. 12 or 1*s*.

2. Some Digestibility Trials on Indian Feeding Stuffs, by P. E. Lander, M.A., D.Sc., A.I.C.; and Pandit Lal Chand Dharmani, L.AG. (Chemical Series, Vol. VII, No. 4.) Price, As. 12 or 1*s*.

3. Papers on Indian Tabanidæ, by P. V. Isaac, B.A., D.I.C., M.Sc., F.E.S.; Two Drosophilidæ from Coimbatore and A New Aphidiphagous Fly, by J. R. Malloch; Notes on Indian Odonata in the Pusa Collection, by Major F. C. Fraser, I.M.S.; On New and Old Oriental Cicindelidæ, by Dr. Walther Horn. (Entomological Series, Vol. VIII, Nos. 5–9.) Price, R. 1-4 or 2*s*.

Bulletin.

4. Tamarind as a Source of Alcohol and Tartaric Acid, by H. N. Batham, M.A.; and L. S. Nigam, L.AG. (Pusa Bulletin No. 153.) Price, As. 3 or 4*d*.

Miscellaneous.

5. Catalogue of Indian Insects. Pt. 4—Trypetidæ (Trypaneidæ), by R. Senior-White, F.E.S., F.R.S.T.M.&H. Price, As. 8 or 9*d*.

LIST OF AGRICULTURAL PUBLICATIONS IN INDIA FROM THE 1ST FEBRUARY TO THE 31ST JULY, 1924

No.	Title	Author	Where published
	GENERAL AGRICULTURE		
1	The *Agricultural Journal of India*, Vol. XIX, Parts II, III and IV. Price, R. 1-8 or 2*s.* per part. Annual subscription, Rs. 6 or 9*s.* 6*d.*	Edited by the Agricultural Adviser to the Government of India.	Messrs. Thacker, Spink & Co., Calcutta.
2	Proceedings of the Board of Agriculture in India held at Bangalore on the 21st January, 1924, and following days, with Appendices. Price, R. 1.	Issued by the Agricultural Adviser to the Government of India.	Government Printing, India, Calcutta.
3	Proceedings of the Cattle Conference held at Bangalore on 22nd and 23rd January, 1924, with Appendices. Price, As. 9.	Ditto	Ditto
4	Annual Report of the Board of Scientific Advice for India for 1922-23. Price, R. 1.	Issued by the Board of Scientific Advice for India.	Ditto
5	Agricultural Statistics of India, 1921-22, Vol. I. Price, R. 1-2.	Issued by the Commercial Intelligence Department of India.	Ditto
6	Estimates of Area and Yield of Principal Crops in India, 1922-23. Price, As. 12.	Ditto	Ditto
7	Quinquennial Report on the Average Yield per Acre of Principal Crops in India for the period ending 1921-22. Price, As. 8.	Ditto	Ditto
8	Poultry Farming in the East. Price, Rs. 4.	Mrs. A. K. Fawkes, Poultry Expert to the Government of United Provinces.	Pioneer Press, Allahabad.
9	Improvement of Paddy Crop with special reference to West Coast Madras Department of Agriculture Leaflet No. 36 (English and Malayalam).	K. Unnikrishna Menon.	Government Press, Madras.
10	Cotton Suitable for Cultivation in the Dry Lands of Kurnool District. Madras Department of Agriculture Leaflet No. 37 (Telugu).	P. H. Rama Reddi, M.A., B.Sc., Deputy Director of Agriculture, III Circle, Madras.	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
11*	Villagers' Calendar, 1924-25 (English, Tamil, Telugu, Malayalam and Kanarese).	Issued by the Department of Agriculture, Madras.	Government Press Madras.
12	Year Book of the Agricultural Department in Sind. Bombay Department of Agriculture Bulletin No. 113. Price, As. 8-6.	Issued by the Department of Agriculture, Bombay.	Government Central Press, Bombay.
13	Studies on the Rice Plant and on Rice Cultivation. Bombay Department of Agriculture Bulletin No. 114. Price, As. 13.	K. V. Joshi, B.Ag., Rice Specialist, and M. V. Gadkari, B.Ag., Assistant to the Rice Specialist, Bombay.	Ditto
14	Shevri as a Fodder Crop. Bombay Department of Agriculture Bulletin No. 115. Price, As. 3.	Issued by the Department of Agriculture, Bombay.	Yeravda Prison Press, Poona.
15	Triennial Report of the Jacobabad Experimental Station for the years 1919-20, 1920-21 and 1921-22. Price, As. 6.	T. F. Main, B.Sc., Deputy Director of Agriculture, Sind.	Government Central Press, Bombay.
16	Annual Report of the Department of Agriculture, Bombay Presidency, for the year 1922-23. Price, R. 1.	Issued by the Department of Agriculture, Bombay.	Ditto
17	The Economic Progress Report of the Rural Areas of the Bombay Presidency, 1911-1922. (For official use only.)	Dr. Harold H. Mann, D.Sc., Director of Agriculture, Bombay, Poona.	Ditto
18	The Reaping of Broadcast Highland Aus Paddy. Bengal Department of Agriculture Leaflet No. 1 of 1924 (English and Bengali).	R. S. Finlow, B.Sc., Director of Agriculture, Bengal.	Bengal Government Press, Calcutta.
19	On the Improvement of Cattle and Economic Welfare. Bengal Department of Agriculture Leaflet (Bengali).	Issued by the Department of Agriculture, Bengal.	Ditto
20	Some Paddies experimented upon and found suitable for the East Bengal Soil. Bengal Department of Agriculture Leaflet No. 3 of 1924 (Bengali).	Ditto	Ditto
21	Water Hyacinth, a Manure for Jute. Bengal Department of Agriculture Leaflet No. 4 of 1924.	R. S. Finlow, B.Sc., Director of Agriculture, Bengal.	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
22	A Systematic History of the Jute Experiments in Bengal. Bengal Department of Agriculture Bulletin No. 2 of 1921.	R. S. Finlow, B.Sc., Director of Agriculture, Bengal.	Bengal Government Press, Calcutta.
23	Report on the Demonstration Work carried out in the Southern Circle, Central Provinces, for 1922-23. Price, As. 8.	J. C. McDougall, M.A., B.Sc., Offg. Deputy Director of Agriculture, Southern Circle, Nagpur.	Government Press, Central Provinces, Nagpur.
24	Reports on the Agricultural Stations in the Southern Circle, Central Provinces, for 1922-23. Price, R. 1.	Ditto	Ditto
25	Report on the Demonstration Work carried out in the Eastern Circle, Central Provinces, for 1922-23. Price, As. 8.	J. C. McDougall, M.A., B.Sc., Offg. Deputy Director of Agriculture, Eastern Circle, Raipur.	Ditto
26	Reports on the Agricultural Stations in the Eastern Circle, Central Provinces, for 1922-23. Price, R. 1 8.	Ditto	Ditto
27	Reports on the Agricultural Stations in the Western Circle, Central Provinces, for 1922-23. Price, As. 8.	S. G. Mutkekar, B.Ag., M.Sc., Offg. Deputy Director of Agriculture, Western Circle, Amraoti.	Ditto
28	Reports on the Agricultural Stations in the Northern Circle, Central Provinces, for 1922-23. Price, Rs. 2.	J. H. Ritchie, M.A., B.Sc., Deputy Director of Agriculture, Northern Circle, Jubbulpore.	Ditto
29	Report on the Experimental Farm attached to the Agricultural College, Nagpur, Central Provinces for 1922-23. Price, As. 8.	R. G. Allan, M.A., Principal, Agricultural College, Nagpur.	Ditto
30	Season and Crop Report, Bihar and Orissa, for 1923-24.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Press, Gulzarbagh.
31	Agricultural Statistics of Bihar and Orissa for 1922-23.	Ditto	Ditto
32	Annual Report of the Department of Agriculture, Bihar and Orissa, for the year ending the 31st March, 1924.	Ditto	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
33	Pusa Pedigree Herd in North Bihar. Bihar and Orissa Department of Agriculture Bulletin.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Press, Gulzarbagh.
34	Silage	C. H. Parr, B.Sc., Deputy Director in charge of Cattle Breeding Operations, United Provinces.	Government Press, United Provinces, Allahabad.
35	Notes on Upper India Hedges.	A. E. P. Griessen, Deputy Director of Gardens, United Provinces.	Ditto
36	Notices regarding Cotton Seed White-flowered (Neglectum Bhatla). Punjab Department of Agriculture Leaflet (Urdu).	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
37	Improved *Gur* Boiling Furnaces. Punjab Department of Agriculture Leaflet No. 24.	Malik Sultan Ali, I.A.S., Deputy Director of Agriculture, Gurdaspur.	Ditto
38	Groundnut and Its Cultivation. Punjab Department of Agriculture Leaflet No. 13 (revised).	Issued by the Department of Agriculture, Punjab.	Ditto
39	Notices on "Cotton Seed" for the knowledge of Zemindars of Lower Bari Doab Colony. Punjab Department of Agriculture Leaflet.	Ditto	Ditto
40	Difference between 4F and 285F Punjab American Cotton. Punjab Department of Agriculture Leaflet No. 28.	Ditto	Ditto
41	Shelter Hedges round Cotton Fields. Punjab Department of Agriculture Leaflet No. 29.	Ditto	Ditto
42	Report on the Operations of the Department of Agriculture, Punjab, for the year ending 30th June, 1923. Price, Rs. 2 or 2*s.* 8*d.*	Ditto	Ditto
43	Prospectus of the Punjab Agricultural College.	Ditto	Ditto
44	Seasonal Notes of the Punjab Department of Agriculture for May 1924. Price, As. 3.	Ditto	Government Printing, Punjab, and Mufid-i-am Press, Lahore.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd		
45	Annual Report on the Operations of the Department of Agriculture, Burma, for the year ended 30th June, 1923.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
46	Annual Reports of Agricultural Stations, Burma, for the year ended 30th June, 1923:—(1) Mandalay, (2) Hmawbi, (3) Mahlaing, (4) Tatkon, (5) Akyab, (6) Hopin, (7) Pwinbyu, (8) Padu, (9) Yawnghwe, and (10) Allanmyo; and Annual Reports of the Agricultural Engineer, Agricultural Chemist, Entomologist, Economic Botanist and Superintendent, Stock-Breeding, for the year ended 30th June, 1923.	Ditto	Ditto
47	Leguminous Crops Cultivated for their Roots, Burma Department of Agriculture Leaflet No. 10.	Ditto	Ditto
48	The Cultivation of Coconut in Arakan. Burma Department of Agriculture Leaflet No. 15.	Ditto	Ditto
49	The Commoner Grasses in Burma. Burma Department of Agriculture Bulletin No. 20.	Ditto	Ditto
50	Notes on Tour in the Coconut [illegible] ricts of Madras Circle, [illegible] Department [illegible] culture Bulletin No. 22.	Ditto	Ditto
51	Agricultural Calendar for 1923-24 (in Burmese).	Ditto	Ditto
52	Preservation of Cowdung. Assam Department of Agriculture Leaflet (Assamese).	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
53	Proper Methods of covering Cows. Assam Department of Agriculture Leaflet (Assamese).	Ditto	Ditto
54	The *Bengal Agricultural Journal* (Quarterly), (in English and Bengali). Annual subscription, R. 1-4; single copy, As. 5.	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.

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	General Agriculture—concld.		
55	The *Journal of the Madras Agricultural Students' Union* (Monthly). Annual subscription, Rs. 4.	Madras Agricultural Students' Union.	The Electri Works, C
56	*Quarterly Journal of the Indian Tea Association.* Price, As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Or Calcutta.
57	*Poona Agricultural College Magazine* (Quarterly). Annual subscription, Rs. 2.	College Magazine Committee, Poona.	Arya Bhu Poona.
58	*Journal of the Mysore Agricultural and Experimental Union* (Quarterly). Annual subscription, Rs. 3.	Mysore Agricultural Experimental Union.	Bangalore Bangalore.
59	*Indian Scientific Agriculturist* (Monthly). Annual subscription, Rs. 4.	H. C. Sturgess, Editor; J. W. McKay, A.R.C.SC., N.D.A., Consulting Editor.	Calcutta Company, Bazar Stree
60	The *Planters' Chronicle* (Weekly).	United Planters' Association of South India, Coimbatore.	E. P. Works,
61	*Rural Bengal* (Monthly) ..	N. N. Gupta, B.A., Ph.D., B.Sc., Editor.	Russa Art Pres pur, Calcutt
62	*Krishak* (Bengali) (Monthly). Price, As. 5 per copy; Annual subscription, Rs. 3-3.	U. C. Bannerji, Editor.	Sri Ram P Bow Bazar Calcutta.
63	*The Old Boys Magazine, Agricultural College, Cawnpore.* (Quarterly). Price, per copy As. 8; Annual subscription, Rs. 2.	M. L. Saksena, L.Ag., Editor.	Cawnpore Pri
	BOTANY		
64	Studies in Indian Tobaccos, No. 4—Parthenocarpy and Parthenogenesis in the varieties of *Nicotiana Tabacum* L. var. *Cuba* and var. *Mirodata*. No. 5—The Inheritance of Characters in *Nicotiana rustica*. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XIII, No. 1. Price, Rs. 2 or 2*s*. 9*d*.	Gabrielle L. C. Howard, M.A., Second Imperial Economic Botanist, Pusa.	Messrs. Thac and Co., Ca
65	Practical Botany for Indian Students.	Diwan Bahadur K. Rangachariar, M.A., L.T.	Government Madras.

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The Wilt Disease of Safflower. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XIII, No. 2. Price, R. 1 or 1*s.* 6*d.*	S. D. Joshi, B.Sc., Research Assistant, Plant Pathological Section, Department of Agriculture, United Provinces.	Messrs. Thacker, Spink and Co., Calcutta.
Jowar Smut. Burma Department of Agriculture Cultivators' Leaflet No. 37.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
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Mahali. Madras Department of Agriculture Leaflet No. 35 (in Malayalam).	M. Govind Kidavu, Deputy Director of Agriculture, VII Circle, Madras.	Government Press, Madras.
AGRICULTURAL BACTERIOLOGY		
Some Studies in Bio-chemistry.	Some students of Dr. Gilbert Fowler, D.Sc.	The Phœnix Printing House, Bangalore.
ENTOMOLOGY		
Report of the Proceedings of the Fifth Entomological Meeting, held at Pusa from 5th to 10th February, 1923. Price, Rs. 9-8.	Edited by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., Imperial Entomologist, Pusa.	Government Printing, India, Calcutta.
Bee-keeping. Pusa Agricultural Research Institute Bulletin No. 46. (Second Edition.) Price, Rs. 2.	C. C. Ghosh, B.A., Assistant to the Imperial Entomologist.	Ditto
The External Morphology and Bionomics of the commonest Indian Tick (*Hyalomma ægyptium*). Pusa Agricultural Research Institute Bulletin No. 152. Price, R. 1.	Mohammad Sharif, M.A., F.R.M.S.	Ditto
Butterflies of India. Price, Rs. 30.	Chas. B. Antram, F.E.S.	Messrs. Thacker, Spink and Co., Calcutta.
Lac Cultivation. Bengal Department of Agriculture Bulletin No. 1 of 1924 (English and Bengali).	Issued by the Department of Agriculture, Bengal.	Bengal Government Press, Calcutta.

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Cotton Insects. Punjab Department of Agriculture Leaflet Nos. 25, 26 and 27.	M. Afzal Hussain, M.Sc., M.A., Entomologist to Government of Punjab, Lyallpur.	Government Punjab Lahor
Rats damaging Paddy. Burma Department of Agriculture Leaflet No. 36.	Issued by the Department of Agriculture, Burma.	Government Burma, Rangn

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Title	Author	Where publi
Proceedings of the Second Meeting of Veterinary Officers in India, held at Calcutta from 26th February to 2nd March, 1923 (with Appendices). Price, R. 1-12.	Issued by the Agricultural Adviser to the Government of India.	Government India, Calcutt
Black Quarter. Madras Civil Veterinary Department Leaflet No. 7.	D. A. D. Aitchison, M.R.C.V.S., Ag. Chief Superintendent, Civil Veterinary Department, Madras.	Government Madras.
Recurrent Orchitis in Donkey Colts at Government Cattle Farm, Hissar. Punjab Veterinary Bulletin No. 4. (Reprinted.)	R. Branford, M.R.C.V.S., Superintendent, Government Cattle Farm, Hissar.	Government Punjab, Lah
Surra Transmission Experiments with *Tabanus albimedius* and Ticks. Punjab Veterinary Bulletin No. 12. (Reprinted.)	Captain H. E. Cross, M.R.C.V.S., Camel Specialist, Sohawa.	Ditto
Prospectus of the Punjab Veterinary College, Lahore.	Issued by the Department of Agriculture, Punjab.	Ditto
Syllabus of Lectures at Punjab Veterinary College.	Ditto	Ditto
Fly Survey Report, Punjab ..	Captain H. E. Cross, M.R.C.V.S., Camel Specialist, Sohawa.	Ditto